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OCTOBER 1943

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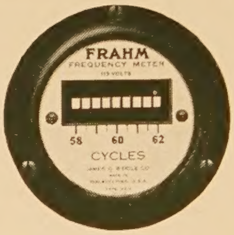

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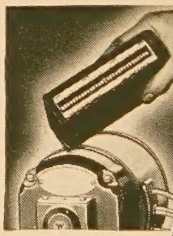
PORTABLE FREQUENCY METER ►



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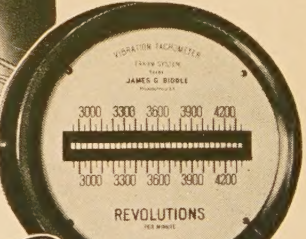
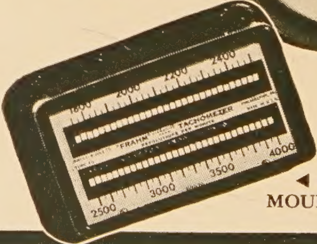


PERMANENT ► MOUNT TACHOMETER



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The Cover: This 5,000-horsepower electric locomotive, one of several recently installed by the New York, New Haven and Hartford Railroad, is said to represent the most improved design added in a 12-year-old program of providing fast high-powered motive power for the railroad's electrified territory.

General Electric Photo

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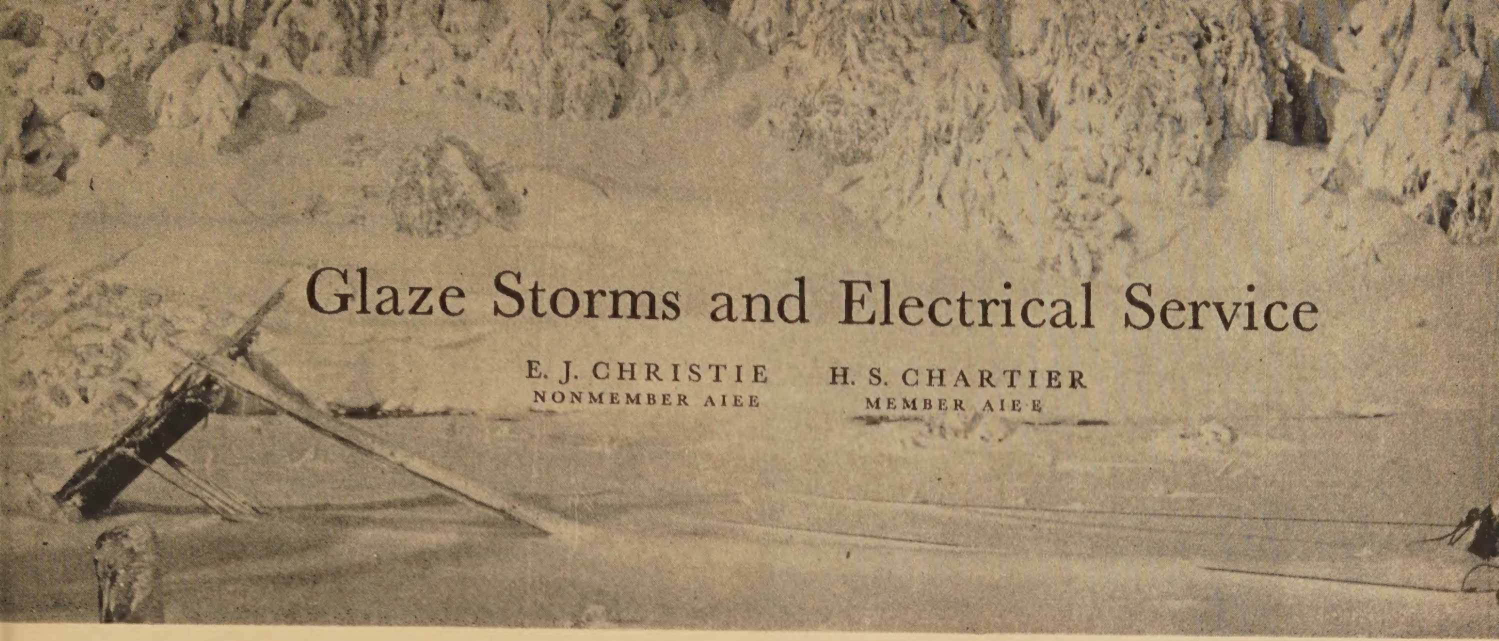


Glaze Storms and Electrical Service

E. J. CHRISTIE
NONMEMBER AIEE

H. S. CHARTIER
MEMBER AIEE

The glaze storm which visited eastern New York State in December 1942 exceeded in area covered and weight of ice any previously recorded, according to the authors of this article, one of whom was active in the repair work throughout the storm and restoration period. The effect of the storm on electric-power systems in the area and the conclusions that can be drawn from it regarding heavy loading conditions due to such storms are discussed.

CHRISTMAS 1942 was followed by the most destructive glaze storm that has been recorded in the central eastern part of New York State. This storm started with rain on the 27th, reached its peak on the 30th, and was followed by snow and subzero temperatures. Another similar but lighter storm followed on the 18th and 19th of January with extreme cold on the 21st. It might be well to examine the mechanics of a glaze storm before describing this one.

All weather is caused or occasioned by air masses as they move across the country—at times by the complete domination of one or the other, the warm or the cold—but most often by the action taking place along the zone which separates them. Cold air masses are dome-shaped, and, therefore, the leading and receding edges of them are wedge-shaped as they progress laterally across the country. As warm moist air is forced upward by the leading edge of a cold mass of air or flows up the slope of the receding edge, it becomes cooled, chiefly because of the expansion taking place with a decrease of pressure, and condensation results. Clouds are formed first, and, if sufficient moisture is condensed, particles of either rain or snow will fall to the earth's surface. The leading edge of a cold air-mass dome forms what meteorologists call the cold front surface, since it is along this surface that the cold dense air forces the warm and lighter air to rise, as the cold air invades the region formerly covered by warmer air. The receding edge is called the warm front surface, because here the warm air rises up the slope more or less of its own accord, as it invades the region formerly covered by cold air.

Glaze or ice storms occur with the warm front type of meteorological situation. The cold mass of air itself moving over a locality cools all objects substantially to its own temperature. If the cooling is of such a degree that the temperature of the objects becomes much below freezing, any moisture then deposited on them freezes immediately. Such is the case when ice storms occur. When the cold air is followed by a mass of warm moist air in which water droplets form above the earth's surface, they drop down through the cold air, strike the cold objects, and adhere immediately thereto in the form of glaze. This happens when the layer of cold air is more or less shallow, whereas, when the cold air layer is thick, the water droplets are cooled sufficiently before arriving at the earth's surface, so that they are frozen, in which case the result is frozen raindrops or sleet (Figure 1).

A very cold mass of Arctic air invaded the northeastern part of the country December 26, 1942, driving temperatures far below freezing during that day and night, and most of Sunday, the 27th. Sunday night it was crested over eastern New York State and central and northern New England, so that its receding edge sloped back to the west and south into Pennsylvania and Ohio. A flow of warm moist air had been moving up from the Gulf of Mexico and during the early evening of the 27th it began to ascend the back slope of the hill of cold air. Sufficient condensation took place to cause light drops of rain to fall through to the earth's surface over much of New York State, and a light coating of glaze occurred.

E. J. Christie is chief meteorologist of the United States Weather Bureau, Albany, N. Y. **H. S. Chartier** is distribution engineer with the New York Power and Light Corporation, Albany, N. Y.

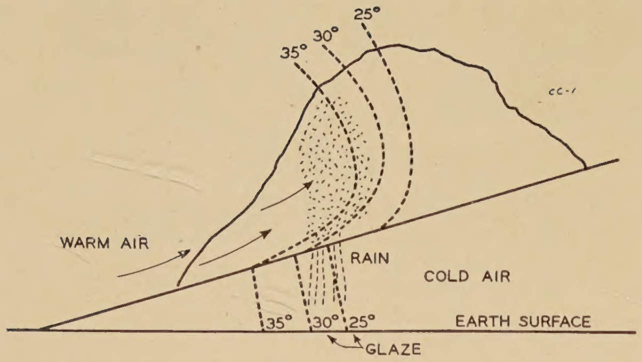


Figure 1. Sketch showing glaze formation

Both air masses kept moving slowly toward the northeast, and the cold mass of air passed on into the Atlantic Ocean area. It was not the end of the freezing rain mechanism, however, for another mass of Arctic air moved southward from the Hudson Bay region on the 28th and slid gently across New York State keeping temperatures down near or slightly under freezing at the earth's surface and providing another slope for the warm air to ascend. The flow of warm moist air from the south continued, and light freezing rain occurred in the eastern half of New York State. On the 29th a definite center of low pressure began to form in the West Virginia area with increasing wind circulation, causing a more pronounced flow of air from the south. During the early morning hours of the 30th this low-pressure area began moving northeastward, intensifying the rain, so that large accumulations of ice resulted, as well as causing the wind to increase. By the next day it had progressed into New England. As soon as the center of this low-pressure area had passed, the winds shifted to the northwest, and colder air once again invaded New York State, but this time the cold front took the upper hand, changing the freezing rain to snow.

The tabulations of temperatures and rainfall given in Tables I and II will assist in an understanding of this storm.

Most of the electrical service to 13 counties in this central eastern area with a population of 785,000 is provided by one public-utility company. This company has 227,000 electric-power consumers along the Hudson and Mohawk River valleys and the adjacent highland. About 86,000 of this total were in the area covered by the storm, and of this number 40,000 were without electric service for periods varying from an hour to, in the most isolated and damaged spots, 17 days.

The affected area is shown on the accompanying map, Figure 2. Contour lines and thickness of glaze are also given. Attention is drawn to the way glaze increased with elevation and to its greater prevalence on the eastern slopes.

Little direct ice damage to lines occurred at elevations less than 500 feet, as up to that height the glaze did not exceed one-half inch in radial thickness. Most troubles in this belt came from falling limbs that caused short circuits on primary lines and burned them down. Interruptions were generally of not more than one or two hours' duration.

Table I. Minimum and Maximum Temperatures

December 27–31, 1942

Station	Elevation	27 Min	27 Max	28 Min	28 Max	29 Min	29 Max	30 Min	30 Max	31 Min	31 Max
Albany	277	4	30	30	34	30	34	31	39	23	31
Cooperstown	1,240	7	32	30	34	32	35	30	37	20	32
Gloversville	850	7	26	26	34	32	34	30	38	20	36
Saratoga Springs	550	0	29	24	35	29	37	30	39	21	40
Sharon Springs	1,360	5	27	27	32	29	32	31	33	19	33
Utica	410	11	31	31	35	32	35	28	39	26	32

In a second zone of elevations between 500 and 1,000 feet glaze was from one-half to one inch in radial thickness. Most of this accumulated during the afternoon and evening of the 29th and the morning of the 30th. The temperature rose to 36 degrees Fahrenheit on the afternoon of the 30th, and with the accompanying warmer rain the ice fell off. Little wire fell from direct ice loading. That which did come down was nearly all numbers 6 and 4 weatherproof copper. Many larger wires were burned off when short-circuited by falling limbs. When the primary wire was 2/0 or larger, even limbs 15 inches through were initially supported by the wire. The conductors were crowded together by the limb causing a short circuit which in most instances tripped the station breaker. The second or third reclosure would burn the wire off, and the whole act would be repeated on the remaining wires. Damage could have been somewhat lessened if all service had been discontinued, and lines killed. Two cities with a population of 35,000 had practically no loads on the stations even though most of the distribution breakers were closed. Interruptions from this cause for the most part were corrected within a 72-hour period after limbs ceased to fall, the speed of the restoration service being subject to the limitation of the man power available.

Services were a source of great trouble in the two cities mentioned. There are 18,000 consumers in this urban and the surrounding rural areas. Over 1,000 services have been replaced and 500 repaired. Where two or three open wires were fastened to a rack on the building, sections of the boards were frequently torn out. If the wires were fastened to single light screw insulators, the building was not damaged, but in either case the conduit

Table II. 24-Hour Precipitation During Period

December 27–31, 1942

Station	27	28	29	30	31	Total
Albany	0.25	0.66	0.57	1.64	T	3.12
Cooperstown	0.	1.75	0.44	1.51	1.72	5.42
Gloversville	0.	0.97	0.31	1.96	1.09	4.33
Saratoga Springs	0.	0.80	0.27	1.70	0.70	3.47
Sharon Springs	0.	1.81	1.00	1.81	0.30	4.92
Utica	1.20	0.62	1.36	1.78	0.10	5.06

was often broken and the wires torn out or burned off (Figure 3). Concentric cable services fastened to the buildings with a four-inch or longer screw hook did not fail unless heavy limbs fell across them. The hook then straightened out, releasing the cable from the house without damaging the boards or interrupting service.

Real ice damage occurred at an elevation of above 1,000 feet. The storm started with a cold rain in the evening of the 27th with the air temperature in the upper 20's. By the morning of the 28th limbs had begun to fall and wires to burn off. Glaze had accumulated to a thickness of five eighths of an inch by six in the evening, and it was practically impossible to maintain any service even though 40 men were massed on as short a line as 3,000 feet of the main street of a small town. Work on restoration was discontinued before midnight, as limbs and trees were falling so often that risk of injury to men was excessive.

Glaze continued to build until evening of the 29th, at which time it varied from one to three inches in radial thickness. Lines were crushed from the weight of ice (Figure 4). Highways were so badly filled with broken trees, poles, and wires that state and other road employees used not only saws and axes but even large snow plows in an attempt to keep the roads open for travel.

This situation was followed by eight inches of snow, lowered temperatures, and a wind of 25 miles per hour. No melting occurred for more than two weeks, and 30 degrees below zero was recorded.

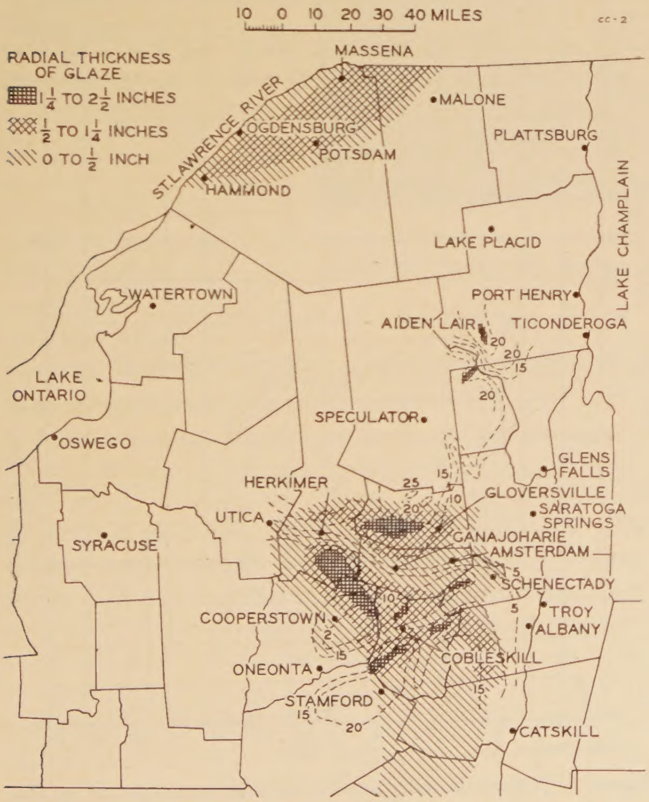


Figure 2. Map of glaze area, eastern New York State, storms of December 28, 1942, and January 21, 1943

– – –*00*– – – *Elevation in hundreds of feet above sea level*

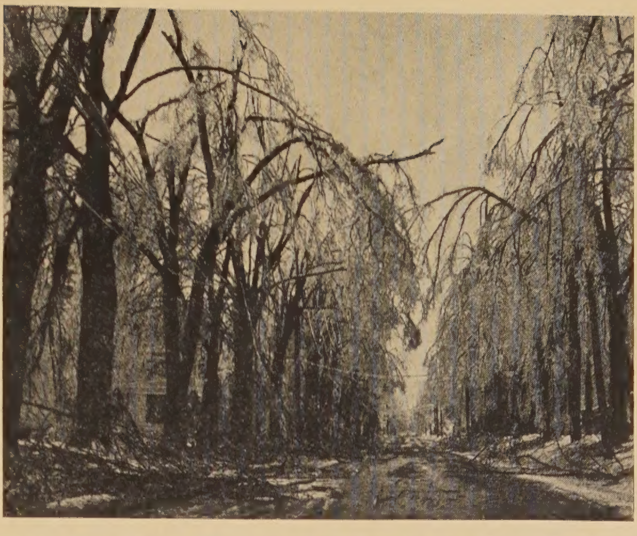


Figure 3. Damage at elevation of 1,300 feet where glaze was one-half to one inch in radial thickness (Main Street, Cherry Valley, December 29, 1942)

It was very fortunate that only small towns and rural lines were located in these areas, as interruptions to service lasted from a few hours to as much as 17 days (Figure 5).

Distribution lines in the villages were largely 20 to 30 years old. Spans were short and the conductors were numbers 6 and 4 weatherproof copper wire with a small amount of number 2. Few poles were broken even though many were old; however, all alley arms failed, and much of the wire was down. Except for burndowns, the number 2 wire was for the most part intact, and on this short span construction dead ends held. The rural sections were all less than 20 years old, many built within the last five years, and chiefly of long span type with high-strength conductors.

Typical of the worst damage was a 30-mile section of rural line about 1,500 feet in elevation where there was not a single span of usable line. Six miles of this consisted of number 2 bare copper wire, three-phase on 225-foot spans, the rest of the line was numbers 4A Copperweld and 2 steel reinforced aluminum cable, with a small amount of number 6 solid steel. All of the last three were single phase with spans from 300 to 500 feet in length. Wires had a kidney-shaped section of ice on the tops and sides one and a half inches or more in thickness, and below was a series of icicles from six to eight inches in length so close together as to form a solid sheet. This loading exceeded three pounds per foot in weight (Figure 6).

Seventy poles were broken in this section. Most of these were dead-end or transformer poles. Many more were tipped partially or completely out of the ground and had to be reset. Dead-end poles with short lead guys (under 15-foot lead) were broken in the middle,

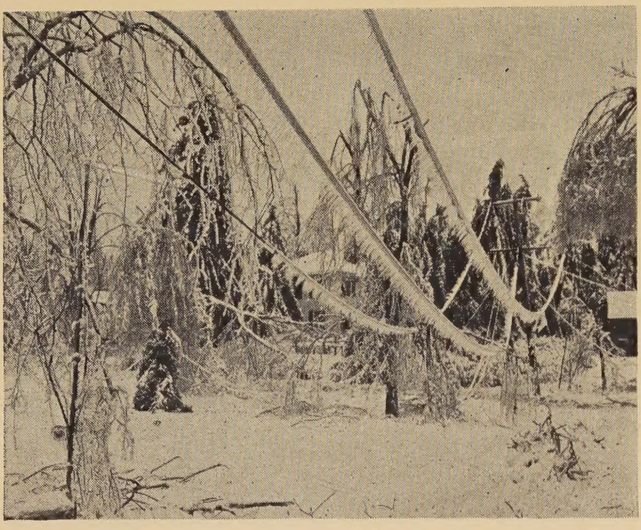


Figure 4. Damage at elevation of 1,400 feet where glaze accumulated to thickness of one to three inches (Main Street, Van Hornesville, January 1, 1943)

while those with long lead guys were broken over the point of guy attachment, and some of these latter could be used temporarily for the restoration of service. Transformer poles failed ten feet or so from the top, possibly from recoil when wires broke.

Single crossarms were almost a total loss. In general, the pins split the wood, but in a few instances the arms were broken over the through bolt. Double arms rarely failed on dead ends, but on angles the pins split them badly. Conductors were naturally broken in many places. These were usually tension breaks, and no one type of conductor material showed any superiority. Greatest conductor damage occurred from snow plows where lines were along or across roads. Few guys larger than 5/16 Siemens-Martin broke. A few anchors pulled up, and two rock anchors broke off.

Complete reconstruction was required in these areas. There was little frost in the ground which was covered with from one to three feet of snow. This combination hampered the work, but some caterpillar equipment was available and was utilized to pull pole butts, raise the new poles, and straighten the tipped poles. Deicing conductors was a major operation. Those that fell early in the storm were frozen in a two-inch layer of ice and had to be broken out, in some cases with a pickax. All had to have the ice shattered foot by foot with hammers or heavy clubs.

Over 325 automatic switch operations were recorded during the storm, and 15 transmission lines were out of service for varying periods. Transmission troubles have not been mentioned thus far, but they are intimately involved with the other interruptions, even though they might not have caused an outage because of other sources of supply.

Early in the storm, with only slightly over $1^1/_4$ inches of ice radially, eight *A*-frame towers fell, presumably from breaking of all conductors in one span. Another case of *A*-frame failure on 110-kv line occurred during the second storm, that of the 18th of January, when five failed with dancing conductors after several trip-outs and one burn-off (Figure 8). It is possible that both of these failures were started by rotation of the channel side sections, because of unbalanced forces from broken or burned off conductors. Additional weight is given this theory as the failures were high in the towers, being at or above the middle. Temporary lines were built on wood poles to permit re-use of these lines until new steel could be obtained and erected.

A wood-pole *H*-frame 110-kv line connecting with another utility system was in the area with the heaviest ice loading, and 46 of the structures built with 55-foot class-*A* poles collapsed (Figure 7). Guyed poles broke over the guys while straight suspension structures failed from 5 to 15 feet below the arm which was of steel. There were no arm failures. The wire was number 4/0 copper, and in some instances the ice had a radial thickness of over three inches. This, together with the sheet of icicles, gave a maximum weight of 14 pounds to the lineal foot. Ice loading exceeded seven pounds per foot for several miles. Failures were progressive and occurred on more than one day.

A light 22-kv single-circuit stub-end line feeding one

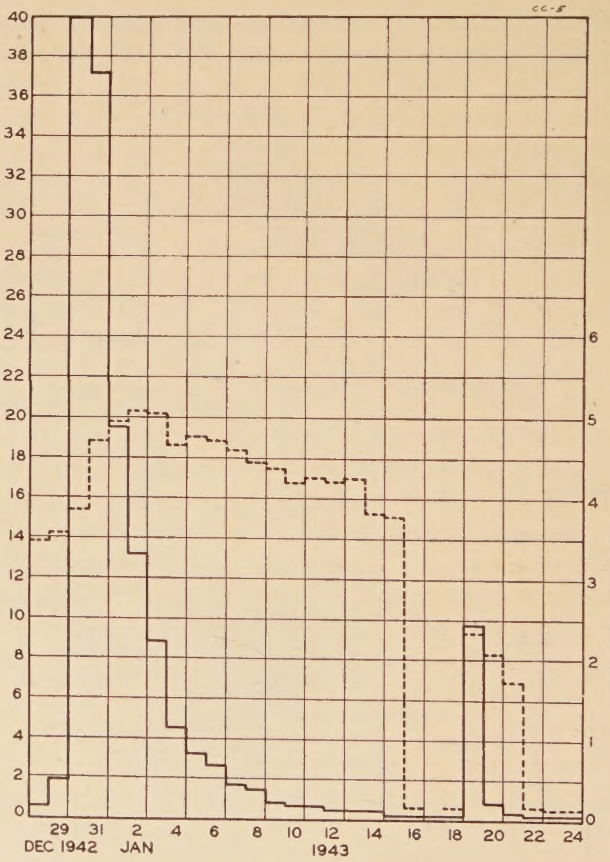


Figure 5. Chart showing number of consumers out of service and number of men required to restore service

——— *Consumers out of service one hour or more*
– – – – – *Men restoring service*

village and rural lines was nearly ruined, having five out of seven miles on the ground with 90 poles broken. Its restoration required $3^1/_2$ days.

The second storm was of short duration, the glaze building in less than a 24-hour period. It covered much the same area as the first storm, but the maximum glaze did not exceed $1^1/_8$ inches radially. Most trouble was from limbs, many of which were broken during the first storm but had not fallen or been removed. Only in one case was there failure from direct ice loading, and then 20 sections of long-span rural line fell.

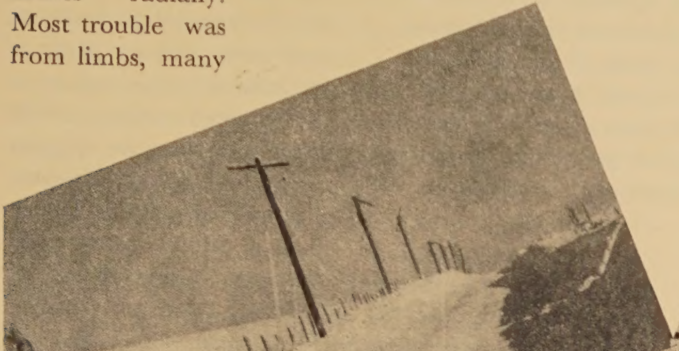


Figure 6 (above). Damage at elevation of 1,500 feet where storm left not a single span of usable line (Willse Hill, three-phase number 2 copper conductors, January 10, 1943)

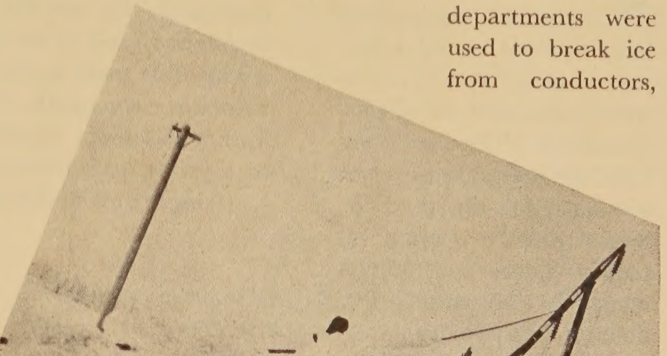


Figure 7 (above). H-frame 110-kv line, 4/0 copper conductors, class-A poles, damaged in storm (Willse Hill, January 2, 1943)

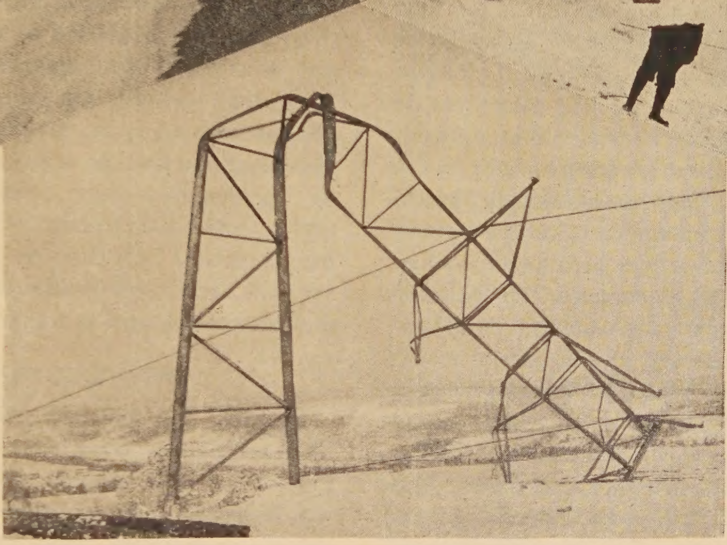


Figure 8. A-frame tower, 110 kv, 336,000-circular-mil steel-reinforced aluminum conductors, damaged in the storm (Pattersonville, January 18, 1943)

After the rain stopped in both storms, there were numerous cases of dancing conductors, both on transmission and distribution. There was also at least one instance of a rather peculiar phenomenon which the authors have seen only once before—a vertical wave or ripple with a 20- or 30-degree front about six inches high traveling from one support to the next, then reflecting and returning with no discernible change in amplitude. It took approximately one second for the wave to traverse the 200-foot span of three-eighths-inch Siemens-Martin ground wire. The conductors and arms in this section had failed, the pins being torn from the arms, possibly from this cause. The temperature was below zero, $1^1/_2$ inches radially of ice on the wire, with about a 15-mile-per-hour cross wind.

Needless to say, all normal means of rapid communication were the first to fail. This made necessary the use of a field force that could be depended upon to act for itself. Only trained linemen can restore lines safely under such difficult conditions without serious damage to personnel. Supervision must be of a high type. Laborers drawn from all departments were used to break ice from conductors, dig holes, and clear trees that had fallen. Engineers were used to survey the damage, to prepare lists of material needed, and to keep track of conditions generally. Some who had extensive operating experience were also used to supervise large areas.

Experience in these storms has indicated that modern construction designed to meet heavy loading conditions is, in general, adequate to carry well up to one inch of radial ice where there are no trees. The use of alley arms should be minimized, as even when doubled they fail early. Guys should be attached to the poles at the point of strain and should have a lead of one or more. Storm guying should be at one-half-mile intervals or less and can be installed easily at angles requiring dead ends. More than one primary circuit should not be carried on a pole. Structures, both transmission and distribution, should be so designed that the arm will be weaker than the supporting member. Dead-end structures should exceed in strength all conductors.

Resonant Electrical Control Systems

DAVID WILLIAM MOORE, JR.

The electrical phase shift between the current and the applied voltage in a series-resonant circuit as the resonant-circuit tuning is varied is used as the basis of operation for resonant electrical control systems. The author discusses application of such systems to aircraft and industrial problems, and to single and multiphase radio control.

REMOTE positioning and control equipments have become essential features in many types of industrial designs and aircraft installations. The increasing trend for centralized control has enlarged the need for mechanisms to operate remotely valves and adjustments. In many installations flexible shafts or mechanical linkages are impractical. A flexible shaft cannot be relied upon for accurate control adjustments if it is too long, or overloaded, or made to traverse short radius bends. It is often impossible to design around these limitations. Where space is an important factor it is sometimes desirable to design the equipment into more components than is functionally necessary to permit utilization of space wherever available. This necessitates the translation of shaft positions from one unit to another, a change which must be done with some type of follow-up system.

Various types of electrical, pneumatic, and hydraulic positioning and control systems have been developed. Many of these are accurate and efficient when no appreciable torque output is required. Power-producing systems have been developed, most of which require electric contactors or long pneumatic tubes and thus increase the maintenance and installation costs. Most of the contact types are of the so-called on–off type, and do not produce a control torque proportionate to the input error signal. Such being true, they are susceptible to hunting if adjusted to permit a high sensitivity.

THEORY OF OPERATION

The control system described in this paper depends for its operation upon the phase-shifting characteristics of a series-resonant electric circuit. The system requires no contacts and may be operated over a wire or radio channel. High-torque low-power operation may be had with no electronic amplifiers.

The series-resonant circuit consists of inductance, capacitance, and resistance in series, with the value of the resistance determining the Q, or efficiency, of the circuit. Figure 1 shows the current and current-voltage phase relationship as the frequency of the applied voltage is varied above and below the resonant frequency of the electric circuit. The current is maximum and in phase with the voltage when the circuit is tuned to resonate with the frequency of the applied voltage. As the applied-voltage frequency is changed slightly, the electric circuit is no longer tuned to resonance, and the phase of the current with respect to the applied voltage shifts rapidly, leading or lagging the voltage, depending upon the direction of the frequency change. This phase shift is rapid to approximately 45 degrees leading or lagging and then asymptotically approaches 90 degrees as the frequency change is continued. The rate of change of this phase shift is a function of the efficiency or Q of the electric circuits, being greater for more efficient circuits. Since this resonant control system is operated by a phase-sensitive servomotor, the efficiency of the electric circuits determines the sensitivity of the control and may be designed to a value consistent with the application and cost of the equipment. In practical resonant control apparatus operating on power frequencies, a Q of five will permit sensitivities of the order of one tenth of one per cent change in frequency or in inductance.

BASIC RESONANT CONTROL

Figure 2 is a schematic diagram of the basic series-resonant control system. The phase-sensitive servomotor used here is the simple two-phase electric motor which has the property of developing torque only when there is an electrical phase differential between the currents in the two phases. Maximum torque is developed when there is an electrical phase differential of 90 degrees between the currents in the two motor phases, and the direction of the torque produced depends upon which motor phase has leading current.

The series-resonant circuit in this system consists of the mechanically variable inductances L_1 and L_2, capacitance C_1, and phase one of the motor. The position transmitter of this system is inductance L_1, which may be varied by rotating its control shaft. It is connected to the position receiver by two electric conductors which may be of considerable length. The position receiving section of the control consists of inductance L_2 which is adjusted by the two-phase servomotor. Phase two of the servomotor is connected directly to the a-c power supply and adjusted to unity power factor by any convenient method, so that the current passing through it is in phase with the applied power-supply voltage.

In the stand-by or equilibrium condition, the series-resonant circuit is adjusted to resonate with the applied voltage and in this condition also passes inphase current.

David William Moore, Jr., is engineer in charge, Fairchild Aviation Corporation, New York, N. Y.

Therefore, the two-phase motor has unity-power-factor current in each phase, and no torque is developed, because there is no electrical phase differential between the currents in the two motor phases. If the position transmitting inductance L_1 is varied by turning its control shaft, the series circuit is slightly detuned and a shift produced in the phase of the current passing through it. This in turn produces an electrical phase differential between the current in the two phases of the servomotor, causing it to develop torque. This torque is used to turn the control shaft of inductance L_2 until it is adjusted so that the series circuit is resonating with the power-supply frequency and until equilibrium again is established. The servomotor at all times tends toward a condition of resonance in the series circuit by maintaining the sum of the inductance values of L_1 and L_2 constant. Therefore, to permit accurate and linear position repeating it is necessary to design the mechanically variable inductances to change their value linearly with input shaft rotation, and to be complementary units, since the value of the inductance in the position receiver must increase as the value of the position-transmitting inductance decreases in order to maintain the sum constant. Figure 3 illustrates the lamination design which produces this type of inductance change, and shows its simplicity, there being no moving coils and consequently no need for brushes and slip rings. This type of inductance is linear for approximately 70 degrees rotation of the control shaft, and accurate position repeating throughout this range may be obtained. Greater ranges may be had by gearing, with no loss in the percentage of accuracy, or by using different inductance design.

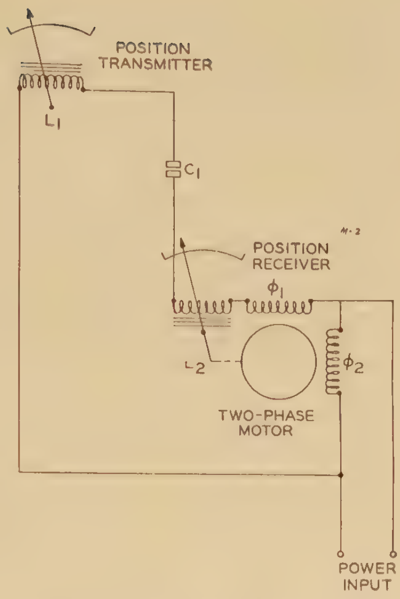


Figure 2. Schematic diagram of the basic series-resonant control system

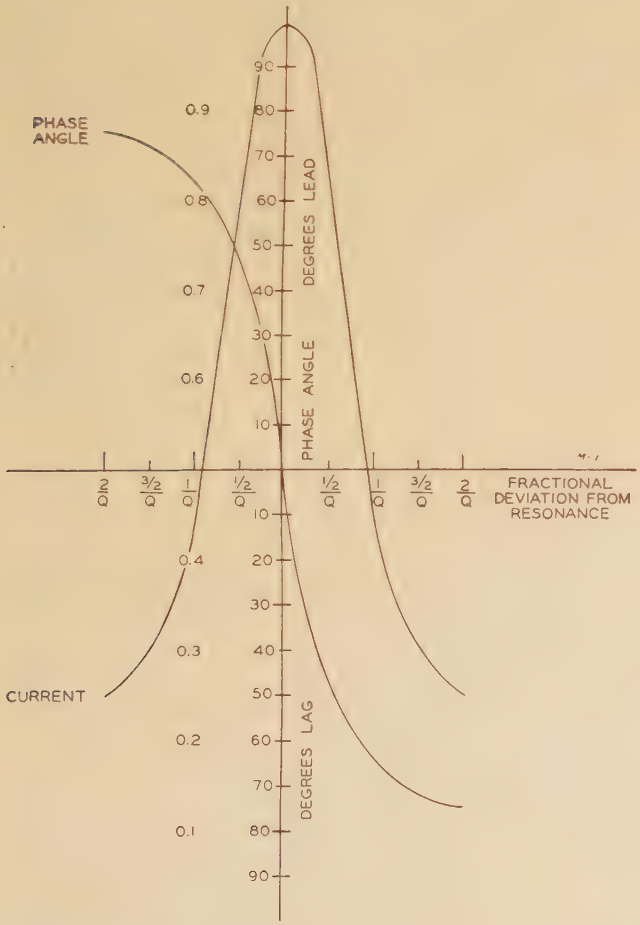


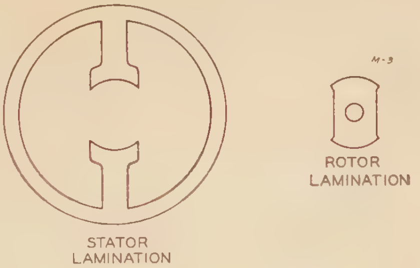
Figure 1. Current and current-voltage phase relationship, as the frequency of the applied voltage is varied above and below the resonant frequency of the electric circuit

The sensitivity of this system is very high near the balance point, because the current is rising to a maximum at low electrical phase angles, permitting the development of substantial torques although the phase differential between the currents in the two motor phases is small.

CONTROL SYSTEM INSENSITIVE TO FREQUENCY CHANGE

This basic control is suitable for operation on controlled frequency systems such as a 60-cycle industrial power supply, but would be upset by mobile electrical systems where the frequency of the applied voltage may shift several per cent. This upsetting is caused by the electrical phase shift in the series-resonant circuit produced by the change in frequency of the power-supply voltage, and has the same effect on the system as a change in phase angle caused by a change in the value of inductance L_1.

Figure 3. Lamination design which produces inductance changes linearly



A system has been devised which is independent of reasonable changes in frequency and is shown in Figure 4. This system consists of the basic resonant control circuit with a second series-resonant circuit added in phase

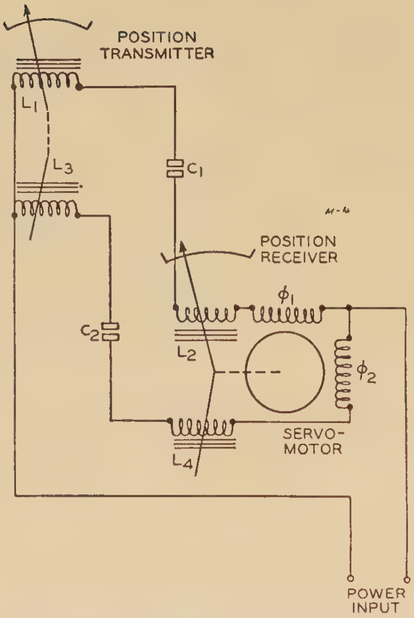


Figure 4. A control system insensitive to changes in frequency

two of the two-phase servomotor. The position transmitter in this frequency-insensitive system consists of inductances L_1 and L_3 which are mounted in the same case and controlled by the same control shaft. They are mechanically arranged so that as the value of inductance L_1 is increasing, the value of inductance L_3 is decreasing. This produces opposite electrical phase differential in the servomotor, causing motor torque which adjusts inductances L_2 and L_4, designed as complements of L_1 and L_3, until resonance is re-established. The sensitivity of this system is greater than that of the basic system, since the phase differential in the servomotor for a given inductance change is doubled as a result of two series-resonant circuits being detuned. If the electric-power supply exciting this system shifts in frequency, each series-resonant circuit is affected in the same manner. Equal phase shifts in the same direction in each circuit are produced, causing no electrical phase differential between the currents in the two motor phases. Consequently, this frequency change does not affect the zero, or balance point, of the control. A system of this type will permit a frequency shift of eight per cent with no serious effect on its operation. Higher frequency shifts do not cause a change in the zero position but are accompanied by serious torque reduction.

PRACTICAL RESONANT CONTROL

A practical follow-up has been constructed in accord with the principle just described. This unit operates from 110 volts at 60 cycles, drawing a maximum power of 14 watts. The torque output is at least 50 inch-ounces per degree error between the position transmitting shaft and the position receiving shaft, with a maximum torque output of approximately 30 inch-pounds at ten degrees error. This unit tracks the position transmitter within one per cent and is sensitive to at least one half of one per cent change of the maximum angular range. This particular unit has been designed for operation on both 50 and 60 cycles, the value of the resonating condensers being changed by means of a toggle switch to insure maximum efficiency on both frequencies.

HIGH POWER OUTPUT

These position repeating systems are limited in power output since the maximum current drain is in the stand-by, or equilibrium, position. After the maximum allowable stand-by current is reached by a system of this type, greater torques and higher power may be obtained by using different phase-sensitive servomotors than the two-phase motor. Thyratron tubes are logical servomotors since they require little control power for large controlled power. If these tubes are used as phase-sensitive controls for servomotors, large powers may be controlled with moderately sized inductances and capacitances.

If the difference between the voltages across two series-resonant-circuit capacitances, as shown in the vector diagram of Figure 5, is used to control the Thyratron grids, the electrical phase of this voltage will always be the optimum angle for firing the tubes. The phase of this difference voltage, as shown in the vector diagram, does not change with the changing phase of the series currents, but is either leading or lagging the electric supply voltage by 90 degrees, depending upon the phase characteristics of the two circuits. Consequently it may be utilized to fire either one of two Thyratrons to control a suitable servomotor.

Air or hydraulic servomotors may also be used if desired. A direct two-phase-motor resonant control system may be used to operate the valve of the servomotor, which adjusts the followup inductance and the mechanism to be controlled. Large powers may easily be handled in this manner with rapid action. Hydraulic power metered by this system could be used for control surface operation on large aircraft to enable positive positioning, or for the operation of large valves.

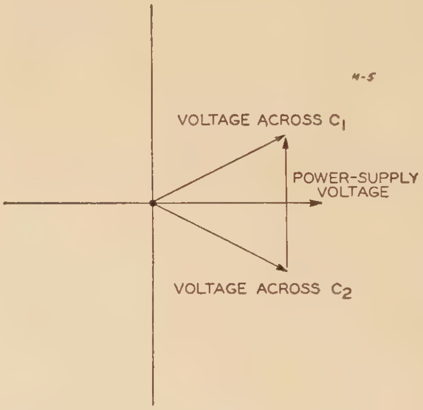


Figure 5. Vector diagram showing the difference between the voltages in phase across two series-resonant-circuit capacitances

TORQUE AMPLIFYING SYSTEM

Figure 6 shows a torque amplifying system suitable for transmitting a low-torque shaft position to an adjacent shaft with increased torque. The resonant control system is a circuit insensitive to frequency changes with the transmitting and receiving inductances combined into one unit. The low-torque shaft varies the position of the inductance rotors, and the servomotor adjusts the induct-

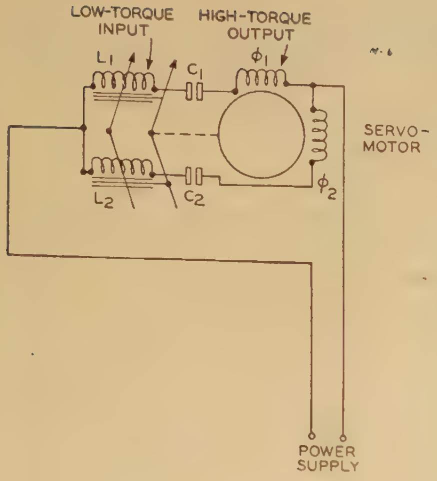


Figure 6. Torque amplifying system for transmitting a low-torque shaft position to an adjacent shaft with increased torque

ance stators, maintaining a resonant condition at all times. Thus a constant mechanical relationship between the stators and rotors of the inductances is assured. This system may be made relatively compact and, with electronic amplifiers, may be made dynamic in action. It is suitable for continuous 360-degree operation.

RADIO CONTROL

All of the systems mentioned so far are suitable for wire operation. Figure 7 illustrates a radio position transmission system capable of definite proportionate position control over a radio carrier. The receiving part of the radio system consists of a variable inductance L_2 and C_2, and a servomotor. Phase one of the servomotor is in series with the inductance and the capacitance, and phase two is made essentially resistive and is connected directly across the alternating-voltage supply, which in this case is the output of the radio receiver. Such a circuit is essentially a frequency meter supplied from the radio receiver. The position transmitter consists of a similar circuit with the servomotor operating an audio-oscillator which is used to modulate the radio transmitter. The transmitter servomotor adjusts the audio-oscillator frequency to the resonant frequency of L_1 and C_1. This frequency modulates the radio transmitter and therefore excites the position receiving circuit, which is adjusted by the receiving servomotor until it is resonating with the applied frequency. If L_1 and L_2 are identical mechanically variable inductances, and C_1 and C_2 are equal, the position of the control shaft of L_1 will be duplicated by the position of the control shaft of inductance L_2. The servomotor in the transmitter is included to permit satisfactory field operation. If the audio-oscillator drifts during warm-up, or at any other time, the servomotor corrects the drift since it maintains the oscillator frequency equal to the resonant frequency of the circuit L_1C_1.

Multichannel radio control may be obtained with the aforementioned radio circuit by assigning a frequency band to each control, or by assigning all of the controls to one frequency band and modulating different subcarrier frequencies with each separate control, filtering them at the receiving end. The carrier system is more satisfactory for a large number of channels, and the individual frequency band system is applicable for the operation of two to four channels. Any type of vehicle could be controlled positively by this system because the control is continuous and not intermittent or based upon a step-by-step arrangement.

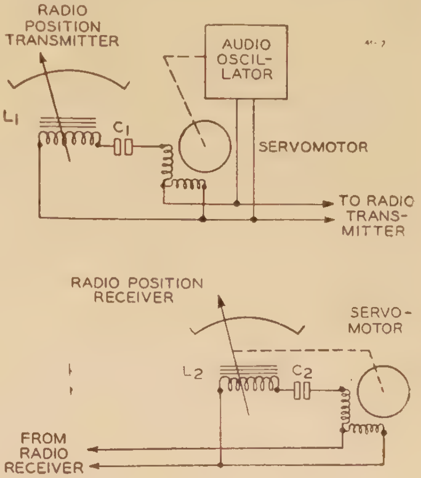


Figure 7. Radio position transmission system capable of definite proportionate position control over a radio carrier

Photo courtesy of Pan American World Airways

Sweden Increases Use of Electricity

AAKE RUSCK

Sweden finds the answer to an increased demand for electric power in the intensified development and expansion of water-power facilities and the reduction of steam-power production dependent on imported coal.

PRODUCTION of electricity in Sweden is based mainly on water power. This condition is quite natural, since the country has great natural resources of water power which can be developed, whereas it has almost no domestic coal. The war and the consequent drop in imports of coal have led to an increased demand for electric power which can be satisfied only through the intensified development and expansion of water-power facilities.

The electric energy produced in Sweden in 1914 amounted to about 1,500,000,000 kilowatt-hours. By 1941 the electric energy output had reached 9,300,000,000 kilowatt-hours. According to the 1938 statistics the individual power consumption in Sweden was two and one half times that in Great Britain.

The distribution of Sweden's electric power before the present war is demonstrated in Table I. From the table it is evident that not less than 80 per cent of the power production was used for industrial purposes. The pulp and wood-working industries required more than one third of the total output; the iron and metal industry was a close second, using more than one fourth of the total output.

Sweden's steam-power production before the war was equal to only about ten per cent of the total electric-power production. Of this, more than one half was so-called "back" pressure power, which can be generated by industries having a fairly large need of steam for heating purposes with relatively small use of coal. Steam power, as well as the comparatively modest production of Diesel power, was required chiefly as a reserve and as a complement to the water-power supply at times of high-power consumption and at low-water periods. A certain portion of steam power was produced through the use of waste products of various industries, such as sawdust and furnace gas, but the principal production of steam power was from imported coal. One of the most important problems of power production after the outbreak of the war was the reduction of steam-power production to a minimum in order to save coal.

The outlook for the power supply at the beginning of the war was favorable because a relatively large production apparatus was dependent on imported coal only to a limited extent. Also, large power stations were then under construction. A widespread high-voltage network connected the country's various sections with each other. Practically all of the country's power stations interchanged power continuously over this network. The electrification of the cities and other municipalities had for a long time been 100 per cent effective, and almost three fourths of the rural households had been electrified by 1939.

Of great importance, also, was the expansion of power-production facilities during recent years, which has been undertaken as a precautionary measure in case of war. A central organization, created to manage the production and distribution of power between the larger power enterprises in the country—national, municipal, and private—had been established wholly through voluntary co-operation, and immediately after the outbreak of the war it began to function. The existing power situation was kept under constant survey by a special national bureau, and the power apportioned according to maximum efficiency in utilization. Through such action it has been possible to satisfy the greatly increased need for power, while at the same time the required portion of steam power was reduced to a minimum of what it had been before the war.

It was evident as early as the autumn of 1939 that new and larger power plants were required. The construction of such plants was begun by the government, by municipalities, and by private enterprises. During the first three years of the war, power stations were added with an aggregate annual production capacity of 1,800,000,000 kilowatt-hours, and during the next two years, it is estimated, new plants with an additional total of 2,200,000,000 kilowatt-hours will be completed. The annual increase in power made possible through these extensions is almost 75 per cent greater than the annual increase during the preceding ten-year period. Most of the new stations will be finished in record time.

Table I. Distribution of Water Power in Sweden Prior to 1939

Channel	Per Cent
Trades, agriculture, households, and illumination	11
Railways and streetcars	9
Mining and metal industries	27
Wood, pulp, and paper industries	36
Chemical–technical industries	7
Other industries	10
Total	100

Aake Rusck is manager of the operating department of the Royal Board of Waterfalls, Sweden.

An example of rapid construction is one large power plant which was begun early in 1940 and started to deliver power in October 1941.

Through modernization and improvement of existing power stations, additional power gains have been obtained. As a result of the vastly extended lake-level regulations, it has been possible to increase greatly the accumulation of water in natural lake reservoirs during periods of plentiful rains for later use when the demand for power becomes higher and the rainfall less.

The establishment of lake-level regulations generally requires lengthy court proceedings. At the request of the water-power producers, the Riksdag, or national parliament, in the autumn of 1939 initiated and passed, within a few weeks, a new law by which court proceedings regarding lake-level regulations during war or danger of war were very much simplified. As a result of this law, it has been possible to effect an increase of over 55 per cent in the natural lake reservoirs.

The steps taken for the expansion of the water-power production apparatus so far have proved successful. After the German occupation of Norway and Denmark there was a temporary decline of power consumption as a result of the export industries being barred from their markets in England and America. This decline, however, has been more than compensated for by the increased use of power for other purposes. The present power production is the largest in the nation's history, and the increase in consumption shows a tendency to continue at a rapid rate.

Such a rise does not seem to depend on a large industrial production, but rather on the increased use of electric energy as a substitute for imported fuels for power and heating. This is quite natural, since the imports have been severely reduced. Moreover, the price level for electricity has been held almost constant, whereas the cost of imported fuels and substitute fuels has risen to several times the former level. The competitive power of electricity has thus improved.

Increased use of power in households for electric cooking and heating, among other things, has added also to the rising power consumption. So has the rural power demand, which has grown rapidly as a consequence of government subsidies and of the shortage of oils for lighting and heating. The scarcity of copper, however, may slow up electrification of rural districts.

The electrification of Swedish railways, principally those owned by the government, has continued during the war years. Almost half of the total track mileage of these railways has been electrified. However, since it is principally the railways with heavy traffic that have been electrified, transportation on the government's lines is handled by electric power up to 85 per cent of the total volume. It has been estimated that the electrification of the railways so far completed has resulted in a saving of about 800,000 tons of coal annually. Railway electrification is of enormous importance to Sweden in these times, when transportation on the country's highways is difficult owing to the lack of oil and rubber. Even electric-trolley bus lines have been pressed into service during the last years.

From the point of view of national sufficiency, Sweden will find advantageous the expansion of power production called forth by the exigencies of war.

Transformer and switch house (above) of the government-owned and -operated Porjus water-power station north of the Arctic Circle in Sweden

(Below). The generating room of the Porjus hydroelectric station in Sweden, blasted 165 feet below ground level to guard against freezing

Professional Aspects of Engineering

HERSCHEL H. ALLEN

A consulting engineer presents his idea of the place the engineering profession should occupy in the community. The engineer's relation to his fellow men, particularly to those involved in the economic development of public improvements and industrial enterprise, and the future of engineering as a profession are important aspects of the article.

ENGINEERING in the industries, in public utilities, and in public work is so intertwined with the legal profession and with the business of government and finance that it is sometimes difficult to draw a line of demarcation where the functioning of one leaves off and another begins. The development of this interrelationship in recent years is largely responsible for the increasing professional status of the engineer. The engineer's work in the eyes of the public—and therefore his professional status—are established by the manner of his dealing with his fellow men—with other engineers, bankers, lawyers, and public officials, whom he contacts in the performance of his professional duties, and with his employer or client.

Finance is the key to public improvements and industrial and utility developments in which the engineer plays an important role. In the division of finance called "New Capital Issues," used for the development of industry and utilities, and the development and conservation of natural resources he has a leading part, and the lawyer and the financier fit their contributions into the plan in order to accomplish what the engineer has envisioned. In this form of finance public officials play a secondary part, because such financing and developments are considered to be private business.

In public finance which make available funds for governmental work by one or more forms of taxation, public officials play a leading role. Next of importance in public finance comes the lawyer because of the legal involvements surrounding public finance and governmental work in general. The roles of the financier and the engineer in public finance are secondary. The former merely bids for the public securities and markets them usually at a small margin of profit, and the latter exercises his technical skill in the preparation of the plans and the supervision of construction, and performs other engineering services necessary to effect the transition from authorized municipal-bond issue to completed public improvement.

Too frequently in the past, financing of private industry and governmental work has been done with too little engineering. The application of sound engineering principles is essential in both instances for the real success of completed developments. Revenue-bond financing on the other hand has been less neglected in this respect for the reason that it is relatively new, although the principle involved is old. This form of financing has been developed within the last 15 years, since engineers have been more active in public affairs, and particularly in the recent past while engineers have taken part in adapting this method of financing to various types of publicly owned facilities. It is applicable to all improvements of a self-liquidating nature. It is a method of financing public works privately through the establishment of a governmental agency to sponsor the revenue-bond issue. Here, the engineers' responsibility is greatest of all. The entire success of a revenue-bond project depends upon the reliability, integrity, and honesty of the engineering reports which form its basis. Here, bonds are sold, and funds are made available for construction purposes when sufficient faith and confidence in the minds of all parties has been established.

Such financing is equitable, in that, the self-liquidating aspects of appropriate projects are developed on the principle that one who uses the resulting facility shall pay for it, but the taxpayer, who has not benefited through its construction, is not taxed for its support. Here, solemn covenants are entered into between the governmental body, authorized by law to issue the revenue bonds, and a trustee, who holds the funds and is responsible for their disbursement. These covenants are usually contained in a document known as a trust indenture. Although the engineering responsibility in such projects is very great, the responsibility of all the others in the covenant is also great, and fullest co-operation between them all is vital to the success of the project. Here, it is necessary for the engineer to understand the law and financing elements for the co-ordination of which he is primarily responsible. Here, also the banker and the lawyer must understand enough of each other's business and enough engineering to assist in bringing about the co-ordination and co-operation which is necessary. And here, the engineering profession has been advanced by new steps toward its rightful place beside the older and more established professions.

DEVELOPMENT OF ENGINEERING IN UNITED STATES

It has been said, "The early engineer in this country was a species of scientific or skilled tramp with a pre-

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Essential substance of an address delivered before the AIEE Maryland Section March 1, 1943.

Herschel H. Allen is partner of J. E. Greiner Company, consulting engineers, Baltimore, Md., and president of the Engineers' Club of Baltimore.

carious tenure of position, measured by the work in progress. He furnished his employer with the skill of his trade without questioning public policy or the best solutions." The transition since then has been slow indeed. The first engineering degree in the United States was conferred in Troy, N. Y., at Rensselaer Polytechnic Institute, in the year 1835. The United States Military Academy at West Point had been teaching science and its application to the military art since the Revolutionary War, and feeble attempts at technical instruction for civilians had been made under Benjamin Hale at Bowdoin College in Maine as early as 1822, but the "application of science to agriculture, domestic economy, the arts and manufactures," as initiated by Stephen van Rensselaer, in 1824, marked the beginning of engineering education in the United States.

In parallel with the industrial trend following the Civil War, engineering courses were started in many colleges and universities. In the 1860's, the number increased rapidly because of the creation of "land-grant colleges" in 1862.

The name "civil engineer" came into usage to differentiate it from military engineering. The offshoots of mining and mechanical engineering were formed in the 1860's of electrical engineering in the 1880's, and of chemical engineering in the 1890's. Today, there are two score offshoot courses in engineering taught at more than 150 engineering schools. These courses now combine scientific, technological, and humanistic subjects. Many have initiated the individual method of laboratory instruction and shopwork. The past 65 years in the development of engineering education have marked an accelerated rise in the status of the engineering profession.

ENGINEERING SERVICES VARIED

Engineering services are numerous and diversified. They are scientific and technical and even extend to the creation of the tools which the scientists themselves use for the discovery of new scientific facts for application by engineers to new uses. They deal with construction problems in all the intricate phases of the modern construction industry. Each new scientific discovery creates some new type of industry required to adapt it to the uses of mankind. Other services include the development and conservation of natural resources and the creation of new public utilities and the extension of existing utilities to provide for the constantly increasing population of our metropolitan areas and industrial communities. Engineers are responsible for the planning of public works and their ultimate financing, construction, and completion.

All of these diversified services require extended contacts on the part of the engineer. The first contact the young engineering graduate makes is his business relationship with his employer. As he gradually develops a professional consciousness, he extends his contacts with his fellow man, and shortly, almost before he is aware of it his interests have been extended in many directions, and he has undertaken wider and more varied problems.

In recent years the management of industries and utilities has been done by engineers trained especially for the work. More recently this has opened a professional-management field with many openings for highly trained capable professional engineers.

Like most of the other professions, the engineer's professional status is unaffected by the terms of his contract; it is outside of and entirely beyond the business relationships which exist between him and his employer. Prerequisite qualifications for successful professional engineering include courage and honesty, both intellectual and moral, which are not concerned with whether his compensation for his technical knowledge consists of a monthly salary or a lump sum fee. Fairness, sound-judgment, and resourcefulness are needed in order to develop a truly professional status. Perseverance, ability to observe closely, accuracy in one's thinking, the drawing of logical deductions and conclusions from the analysis of situations and conditions, and ability to co-operate with others and organize one's work, assistants, and staff are matters beyond the realm of technical training. They embody the extra punch needed to realize the advanced place in society for which all engineers have striven for many years. They are those qualifications needed for conducting one's personal contacts with financiers, lawyers, and public officials, as well as with one's employers and clients, that mark the engineer as a proper recipient of the special privileges extended by society to the professional man. Every engineer who can call these characteristics his own is on his way to the top of his profession and to recognition in the community.

Willard Chevalier has said, "There is something bigger, more vital, and more fundamental in professional relationships than you can write into a statute." This statement was made because of the intense campaign for professional status which has taken the form of legal registration in many of the states during the last few years. The truth of Mr. Chevalier's statement is becoming increasingly apparent to most engineers. Among engineers there exists, now, a better recognition of the distinction between technology and the wider comprehension prerequisite to a professional status.

The possession and practice of a high order of technical skill do not in themselves make an individual a professional man. Technical training alone is merely vocational, rather than professional. The difference between technical training and professional education is a matter of spirit and ideals, even more a matter of a certain supercharge in the man beyond the mere ability to accomplish the day to day tasks of life.

PROFESSIONAL TRAINING

Professional education for the lawyer means more than training himself to prepare legal documents or to try cases in the courts. It encompasses studying history, philosophy, and the social institutions out of which the law has developed. Legal education began in this country, in 1784. Prior to that time, colonists desiring legal training studied in England. From then until 1829, when college training of lawyers began in this country, law students were taught by a system known as "apprentice training." College teaching continued for about 50 years prior to 1880, before the scientific study of jurisprudence was started. The complexity of governmental functions and the passage of the multitudinous laws which are being ground out in our legislative halls in all the states and in Washington would indicate that the education of lawyers may, in the near future, have to start a fourth phase. At the present time, there is about one lawyer for each 1,000 inhabitants in this country. There are two schools of thought as to the proper method of controlling the personal qualifications and standards to be maintained in the legal profession. In the older jurisdictions, a rigorous course of preparation is advocated to promote competency and character among the lawyers. In the younger jurisdictions, democratic idealism is preferred, and almost all oppose making requirements for preparation unduly difficult.

The engineering profession may never be confronted with a similar problem. The rapid recent advances of technology, the kaleidoscopic changes effected by new scientific developments requiring revolutionary changes in methods of production all contribute to an increasing need of technologists and technicians. If this advance is continued during the period following World War II at the rate it has maintained since World War I, it appears that no sort of restrictive measures will be needed for the selection of the individuals to whom engineering will be taught. On the other hand, preliminary training preceding technical education may have to be intensified to produce technically trained engineers equal to the wants.

We have seen the reverse of this situation during the last few years. The technical training of many of our engineering graduates during the early 1930's has slipped away from the individuals and has been lost to society completely as a result of the inability of these young engineers to practice their technique and continue the assimilation of knowledge so essential to the development of true engineering.

Professional education for the engineer means not only gaining skill in the application of the sciences and mathematics, but also philosophic insight into the sciences and their application to human needs and advancement. The professional status involves a knowledge of social forces and institutions which will enable one to view his work and its consequences not only as a service to employer or client, but also in terms of its benefits to society.

THE ENGINEERING ATTITUDE

There are too many engineers with a narrow and petty attitude about matters of sharing knowledge and advances in professional practice. An engineer's skill is his personal possession, and when he imparts it to another he rightly expects a reasonable remuneration. His knowledge, however, is a part of a common fund which has been passed down through the years, which he shares with others, and to which he is obligated to add, personally, if he possesses the ability—if not, then through the medium of the Founder Societies and other engineering organizations which have been created for preservation and dissemination of professional knowledge.

The difference between a technical vocation and a profession is the supercharge of personality and powers of expression to fit one for a place of influence in the community.

To those men who have been left on the station platform when the train pulled out, who do not see beyond the results of today's work, whose jobs are sources of livelihood only, the attainments of others are often subjects of envy. These men have let their scientific training slip away after college days; they contribute nothing to advancement and exert little or no influence in their communities. But their case is not as hopeless as it sounds, for few men do not display unsuspected personal charms when exposed to conditions which bring out the best in them. It is entirely up to them; all that is needed is the extra will to do.

The daily routine of members of many other professions compels them to study continuously. These are what might be termed contemplative vocations. An engineer, however, leads a life of action rather than one of research and consequently is not given to continuous study. The added drive is therefore much more essential in his case than in other professions. But far too many engineers rely on ordinary experience for the assimilation of additional knowledge without definite mental discipline.

ENGINEERING FUTURE

The future of the engineering profession depends upon its members who not only can produce technical results and business profits, but who can be looked to for the advancement of improved methods and products—men who can be trusted with confidences between agent and client and who can help to shape the policies which guide our future development. Leadership in engineering as in other fields is for men who can combine determined action and intellectual advancement.

During the years to come it seems to me inevitable that industry will be flung to the far corners of the earth. Production will be developed more and more scientifically, and with it all research will expand into ever wider fields, and engineers will increase in numbers and in ability to meet the call. And so, when one asks: "What place does the engineer occupy in civilization?" the reply is not just the turbine, dynamo, bridge, or highway, and not even just the broader relationship as concisely expressed by Karl T. Compton: "Science seeks to understand nature while engineering seeks to control nature." To this it should be added that other engineers, his employer and client, the banker, lawyer, and politician form the engineer's field of human contacts, and the breadth of his relationships form the yardstick to measure his professional status and worth in the community.

The past 100 years of engineering accomplishment is an unparalleled record. It has, of course, been brought about by contemporary scientific advancement. But the changes in educational procedure, the enlargement of the field to include an ever increasing number of specialties, and the strides made toward reaching the goal of public acceptance point to the near future when engineering will occupy the same honored place in society as the other professions, a goal toward which engineers have been striving. It is our duty to supercharge ourselves and put in the extra punch needed to reach this goal.

Refresher for Dielectric Calculations

E. W. GREENFIELD
MEMBER AIEE

In making dielectric calculations, it is important to be able to correlate the fundamental characteristics of the dielectric material with measured quantities such as current, loss, power factor, and capacitance. In this article the author has attempted to co-ordinate in a simple manner all the relations necessary to dielectric computation.

MANY experimenters faced with measurement on insulation materials for the first time or having only an occasional necessity for dielectric measurements find the literature somewhat scattered and confusing with regard to terminology, relationship of basic concepts, and calculation of results.

The two fundamental characteristics of any dielectric material are

1. Equivalent conductivity (or its reciprocal, resistivity).
2. Dielectric constant.

The relative magnitude of these properties and the manner in which those magnitudes change with variation in applied potential, frequency, temperature, and so forth, completely describe the material from every standpoint. Electrical measuring instruments, in general, do not measure directly the fundamental material characteristics. It is therefore important to be able to correlate these with the measured quantities such as current, loss, power factor, and capacitance, and also to be able to interpret these parameters in terms of the unavoidable geometry of the electrode measuring system.

The equations presented here attempt to co-ordinate in a simple manner all the relations necessary to dielectric computation. These relations have accumulated in the author's notebook for the past several years. It is possible that others may find them as useful as he has.

CAPACITOR–RESISTOR REPRESENTATION

The appendix contains a general summary of all dielectric terms for any insulating material which can be represented by a simple parallel capacitor–resistor scheme. Such circuit representation applies to all types of capacitor and cable systems, when the frequency is sufficiently low so that series resistance and inductance of the leads and of the electrodes themselves are negligibly small.

The relations are derived in the practical system of electromagnetic units and permit maximum convenience in correlating the various factors. The equations assist conversion of such readily measurable quantities as voltage, current, dissipation factor, and capacitance, to the more basic parameters which characterize the dielectric material itself. The procedure may also be reversed as occasion demands.

The importance of the two basic characteristics of a dielectric, that is, conductivity and dielectric constant are clearly brought out by equation 44 or 45. It is

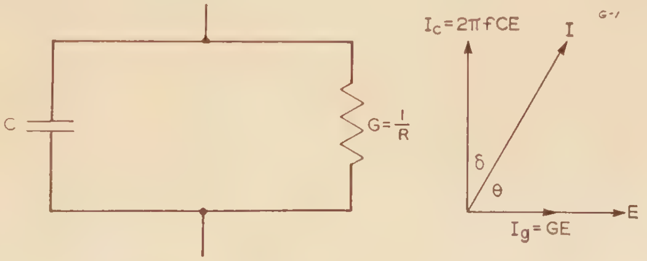

Figure 1. Equivalent circuit and vector diagram of dielectric

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E. W. Greenfield is head of the electrical laboratory, engineering department, Anaconda Wire and Cable Company, Hastings-on-Hudson, N. Y.

Table I. Geometric Capacitance, Conductance, and Resistance for Parallel Plates*

System Dimensional Units	Capacitance, C_o			Conductance (Mhos) G_o	Resistance (Ohms) R_o
	Farads	Microfarads	Micro-microfarads		
Centimeters	$8.85\times10^{-14}\frac{A}{t}$	$8.85\times10^{-8}\frac{A}{t}$	$8.85\times10^{-2}\frac{A}{t}$	$\frac{A}{t}$	$\frac{t}{A}$
Inches	$2.25\times10^{-13}\frac{A}{t}$	$2.25\times10^{-7}\frac{A}{t}$	$0.225\frac{A}{t}$	$2.54\frac{A}{t}$	$0.394\frac{t}{A}$
Feet	$2.70\times10^{-12}\frac{A}{t}$	$2.70\times10^{-6}\frac{A}{t}$	$2.70\frac{A}{t}$	$30.5\frac{A}{t}$	$3.28\times10^{-2}\frac{t}{A}$
Mils	$2.25\times10^{-16}\frac{A}{t}$	$2.25\times10^{-10}\frac{A}{t}$	$2.25\times10^{-4}\frac{A}{t}$	$2.54\times10^{-3}\frac{A}{t}$	$3.94\times10^{2}\frac{t}{A}$

*See Figure 2.

shown that as far as the dielectric material itself, dielectric loss is entirely a function of conductivity alone; whereas, wattless power (charging current) is entirely a function of dielectric constant. All other characteristics, such as power factor, dissipation factor, and loss factor, are arbitrarily defined ratios which sometimes have more practical advantage when dielectric quality is being interpreted.

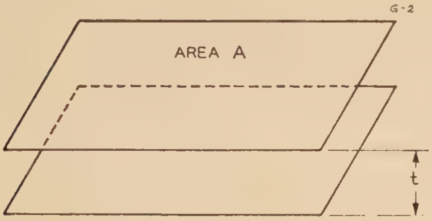

Figure 2. Parallel plates

See Table I

The two characteristics of any dielectric system which are of greatest practical importance to the user are

1. The total current drawn.
2. The total watt power consumed.

From a knowledge of the conductivity and dielectric constant of a given material, one calculates the specific current (equation 45) and the specific loss (equation 55). To determine the total current and dielectric loss for any particular capacitor or cable size operating at any given voltage, it is then only necessary to multiply the specific current and specific loss by the appropriate geometry and voltage factors.

INTERPRETATION OF ELECTRODE GEOMETRY

Dielectric measurements are always made with the material under investigation between some type of metallic electrode system. Hence, measurements on dielectrics always yield the parameters, conductance (or resistance) and capacitance, which are functions of both the fundamental material characteristics and the extent and geometry of the particular electrode system. The geometry of the electrode system is generally made as simple and regular as possible but at times may be very complex.

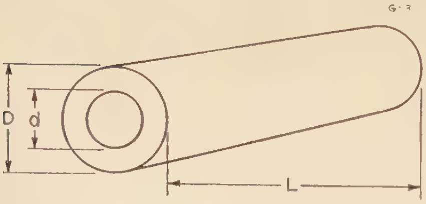

Figure 3. Coaxial cylinders

See Table II

To eliminate the influence of the electrode system from the measurement, one divides the measured conductance or capacitance by an appropriate geometric factor; the result is conductivity or dielectric constant, both of which are peculiar to the material alone. Conversely, these material properties are in such unit form that, when they are multiplied by the suitable geometric factor relating to any contemplated electrode system, total conductance (or resistance) and capacitance are obtained.

The appendix also presents in a systematic manner the equations for these geometric factors appropriate to any desired electrode system. Tables I through IV, therefore, supplement the equations relating to a simple dielectric. In effect, the equations given in these tables enable one to determine the C_o, λ, and ρ required in the equations of the appendix.

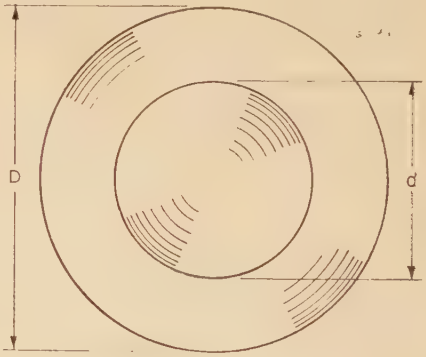

Figure 4. Concentric spheres

See Table III

It should be noted in particular that the geometric factors relating to conductance and resistance are treated in exactly the same manner as for the more familiar geometric capacitance. This makes for a consistency which has generally been lacking.

Table II. Geometric Capacitance, Conductance, and Resistance for Coaxial Cylnders*

System Dimensional Units	Capacitance, C_o			Conductance (Mhos) R_o	Resistance (Ohms) G_o
	Farads	Microfarads	Micromicrofarads		
Centimeters	$2.42\times10^{-13}\dfrac{L}{\log D/d}$	$2.42\times10^{-7}\dfrac{L}{\log D/d}$	$0.242\dfrac{L}{\log D/d}$	$2.73\dfrac{L}{\log D/d}$	$0.366\dfrac{\log D/d}{L}$
Inches	$6.14\times10^{-13}\dfrac{L}{\log D/d}$	$6.14\times10^{-7}\dfrac{L}{\log D/d}$	$0.614\dfrac{L}{\log D/d}$	$6.94\dfrac{L}{\log D/d}$	$0.144\dfrac{\log D/d}{L}$
Feet	$7.36\times10^{-12}\dfrac{L}{\log D/d}$	$7.36\times10^{-6}\dfrac{L}{\log D/d}$	$7.36\dfrac{L}{\log D/d}$	$83.3\dfrac{L}{\log D/d}$	$1.20\times10^{-2}\dfrac{\log D/d}{L}$
Mils	$6.14\times10^{-16}\dfrac{L}{\log D/d}$	$6.14\times10^{-10}\dfrac{L}{\log D/d}$	$6.14\times10^{-4}\dfrac{L}{\log D/d}$	$6.94\times10^{-3}\dfrac{L}{\log D/d}$	$1.44\times10^{3}\dfrac{\log D/d}{L}$

*See Figure 3.

Appendix

Every dielectric is characterized by a conductivity, λ, and a dielectric constant, ϵ'.

Conductivity, in general, varies with temperature and frequency. Its component due to ionic conduction is little dependent on frequency. Its component due to absorption losses (polar interfacial, and so forth) is dependent on both frequency and temperature.

Dielectric constant, in general, varies with temperature and frequency. Its component, arising from normal polarization of the dielectric, varies with temperature in a manner roughly directly proportional to change of specific gravity. It generally decreases with frequency. Its component, arising from dielectric absorption, varies with temperature and frequency and exhibits anomalous dispersion at regions of absorption maxima.

FORMULAS FOR DIELECTRICS (SEE FIGURE 1)

All units are the practical units, that is, watts, volts, amperes, ohms, mhos, farads, and so forth.

Capacitance $C=\epsilon' C_o$ (1)

Geometric capacitance $C_o=\dfrac{C}{\epsilon'}$ (2)

Dielectric constant $\epsilon'=\dfrac{C}{C_o}$ (3)

$=\dfrac{\epsilon''}{\tan\delta}$ (4)

$=\dfrac{1}{2\pi f C_o}\cdot\dfrac{G}{\tan\delta}$ (5)

$=\dfrac{1.8\cdot10^{12}}{f}\cdot\dfrac{\lambda}{\tan\delta}$ (6)

Loss current $I_g=GE$ (7)

$=2\pi f C_o\epsilon'' E$ (8)

$=11.3\cdot10^{12}\cdot C_o\lambda E$ (9)

Charging current $I_c=2\pi f CE$ (10)

$=2\pi f C_o\epsilon' E$ (11)

Conductance $G=\dfrac{I_g}{E}$ (12)

$=2\pi f C_o\epsilon''$ (13)

$=2\pi f C\tan\delta$ (14)

$=11.3\cdot10^{12}C_o\lambda$ (15)

$=\dfrac{P}{E^2}$ (16)

Conductivity $\lambda=0.556\cdot10^{-12}f\epsilon''$ (17)

$=0.556\cdot10^{-12}f\epsilon'\tan\delta$ (18)

$=\dfrac{1}{11.3\cdot10^{12}C_o}\cdot\dfrac{P}{E^2}$ (19)

$=\dfrac{1}{11.3\cdot10^{12}}\cdot P$ (20)

Resistance (insulation) $R=\dfrac{1}{G}$ (21)

Resistivity $\rho=\dfrac{1}{\lambda}$ (22)

Power factor $\Delta=\cos\theta$ (23)

Table III. Geometric Capacitance, Conductance, and Resistance for Concentric Spheres*

System Dimensional Units	Capacitance, C_o			Conductance (Mhos) G_o	Resistance (Ohms) G_o
	Farads	Microfarads	Micromicrofarads		
Centimeters	$0.556\times10^{-12}\dfrac{Dd}{(D-d)}$	$0.556\times10^{-6}\dfrac{Dd}{(D-d)}$	$0.556\dfrac{Dd}{(D-d)}$	$6.28\dfrac{Dd}{(D-d)}$	$0.159\dfrac{(D-d)}{Dd}$
Inches	$1.41\times10^{-12}\dfrac{Dd}{(D-d)}$	$1.41\times10^{-6}\dfrac{Dd}{(D-d)}$	$1.41\dfrac{Dd}{(D-d)}$	$16.0\dfrac{Dd}{(D-d)}$	$6.26\times10^{-2}\dfrac{(D-d)}{Dd}$
Feet	$1.70\times10^{-11}\dfrac{Dd}{(D-d)}$	$1.70\times10^{-5}\dfrac{Dd}{(D-d)}$	$17.0\dfrac{Dd}{(D-d)}$	$1.92\times10^{2}\dfrac{Dd}{(D-d)}$	$5.22\times10^{-3}\dfrac{(D-d)}{Dd}$
Mils	$1.41\times10^{-15}\dfrac{Dd}{(D-d)}$	$1.41\times10^{-9}\dfrac{Dd}{(D-d)}$	$1.41\times10^{-3}\dfrac{Dd}{(D-d)}$	$1.60\times10^{-2}\dfrac{Dd}{(D-d)}$	$62.6\dfrac{(D-d)}{Dd}$

*See Figure 4.

Table IV. Geometric Conductance and Resistance for Any Electrode System Where the Geometric Capacitance Is Known

For C_o Expressed in	Conductance (Mhos) G_o	Resistance (Ohms) R_o
Farads	$1.13\times10^{13}C_o$	$\frac{8.85\times10^{-14}}{C_o}$
Microfarads	$1.13\times10^{7}C_o$	$\frac{8.85\times10^{-8}}{C_o}$
Micromicrofarads	$113C_o$	$\frac{8\ 85\times10^{-2}}{C_o}$

Power factor

$$\Delta=\frac{I_g}{I} \tag{24}$$

$$=\sin\left(\tan^{-1}\frac{\epsilon''}{\epsilon'}\right) \tag{25}$$

$$=\sin\left(\tan^{-1}\frac{I_g}{I_c}\right) \tag{26}$$

$$=\sin\left(\tan^{-1}\frac{G}{2\pi fC}\right) \tag{27}$$

$$\simeq\frac{G}{2\pi fC}\ \text{(for }\tan\ \delta<0.1) \tag{28}$$

Dissipation factor

$$D=\tan\ \delta \tag{29}$$

$$\doteq\frac{G}{2\pi fC}=\frac{I_g}{I_c} \tag{30}$$

$$=\frac{P}{I_cE} \tag{31}$$

$$=\frac{P}{2\pi fCE^2}=\frac{P_s}{2\pi f\epsilon'} \tag{32}$$

$$=\frac{\epsilon''}{\epsilon'} \tag{33}$$

$$=\frac{1.8\cdot10^{12}}{f}\cdot\frac{\lambda}{\epsilon'} \tag{34}$$

Loss factor

$$\epsilon''=\epsilon'\ \tan\ \delta \tag{35}$$

$$=\epsilon'\frac{G}{2\pi fC} \tag{36}$$

$$=\frac{G}{2\pi fC_o} \tag{37}$$

$$=\frac{1}{2\pi fC_o}\cdot\frac{1}{R} \tag{38}$$

$$=\frac{1.8\cdot10^{12}}{f}\cdot\lambda \tag{39}$$

$$=\frac{1.8\cdot10^{12}}{f}\cdot\frac{1}{\rho} \tag{40}$$

Current

$$I=\sqrt{I_g{}^2+I_c{}^2} \tag{41}$$

$$=E\cdot\sqrt{G^2+(2\pi f)^2C^2} \tag{42}$$

$$=2\pi fC_oE\sqrt{(\epsilon'')^2+(\epsilon')^2} \tag{43}$$

$$=2\pi C_o\cdot E\sqrt{(1.8\cdot10^{12})^2\lambda^2+f^2\epsilon'^2} \tag{44}$$

Specific current

$$i_s=2\pi\sqrt{(1.8\cdot10^{12})^2\lambda^2+f^2\epsilon'^2} \tag{45}$$

$$i_s=2\pi f\cdot\epsilon'\sqrt{\tan^2\ \delta+1} \tag{46}$$

(that is, current per unit volt per unit geometric capacitance)

Power loss

$$P=I_gE \tag{47}$$

$$=I_cE\tan\delta \tag{48}$$

$$=IE\cos\theta \tag{49}$$

$$=IE\sin\delta \tag{50}$$

$$=GE^2 \tag{51}$$

$$=2\pi fCE^2\tan\delta \tag{52}$$

$$=11.3\cdot10^{12}\cdot C_oE^2\lambda \tag{53}$$

$$=C_oE^2\cdot P_s \tag{54}$$

Specific loss

$$P_s=(11.3\cdot10^{12})\cdot\lambda \tag{55}$$

$$=2\pi f\epsilon'' \tag{56}$$

$$=2\pi f\epsilon'\tan\delta \tag{57}$$

(that is, loss per unit $\overline{\text{volt}}^2$, per unit geometric capacitance)

USEFUL GEOMETRIC FACTORS FOR THE CALCULATION OF DIELECTRIC CHARACTERISTICS

1. *Fundamental Relations.* Specific inductive capacity (dielectric constant),

$$\epsilon'=\frac{C}{C_o} \tag{3}$$

where C = measured capacitance
and C_o = geometric capacitance (in the same units as C)

Specific conductance (insulation conductivity):

$$\lambda=\frac{G}{G_o}\text{mhos per centimeter} \tag{58}$$

where G = measured conductance
G_o = geometric conductance (in same units as G)

Specific resistance (insulation resistivity):

$$\rho=\frac{R}{R_o}\ \text{ohm-centimeters} \tag{59}$$

where R = measured resistance
R_o = geometric resistance (in same units as R)

The terms C_o, G_o, and R_o are thus analogous and may be denoted as dielectric *geometric factors.*

2. *Tables of Geometric Factors.* Tables I, II, and III give in a systematic manner the geometric factors relating to dielectric constant, conductivity, and resistivity for the three electrode systems, that is, *parallel plates*, *coaxial cylinders*, and *concentric spheres.*

In every case, the geometric factor, whether capacitance, conductance, or resistance, is given in erms of the practical electrical unit and the centimeter dimension. Hence, when the geometric conductance and resistance terms are used in equations 58 and 59 the resultant specific parameters will be in terms of mhos per centimeter and ohm-centimeters respectively.

Table IV is of great value for the determination of conductivity and resistivity when the electrode-system geometry is either unknown or too complex for calculation. In these cases, the conductance and resistance geometric factors may be determined from the tabulated equations if the geometric capacitance (C_o) of the electrode system is known or can be measured.

In the case of the parallel-plate and coaxial-cylinder electrode systems, they are assumed to be either "infinite" in extent or to be sufficiently defined by suitable guard electrodes.

All numeric constants appearing in the tables are given only to the third place.

Small A-C Generators and Their Applications

ARTHUR JAMES GIRDWOOD
ASSOCIATE AIEE

Too often an engineering "orphan," the small a-c generator, nevertheless, is important in its sphere. Factors related to the design and application of these units are discussed herein.

ALTHOUGH some attention has been given to manufacturing problems and to the production of compact units which could be put on the market as a standardized product in the interests of best economy, the small generator and its system too often has been an engineering orphan. Standardization is highly desirable and should be maintained wherever possible, but within the limit of best over-all economy to all concerned.

Until recent years there were relatively few sales of small a-c generating units in Canada. A series of events, however, has raised Canada's investment in these machines to impressive proportions. The first of these was the increase in the price of gold, a condition which resulted in the establishment of many small mining ventures beyond the reach of power systems. Then, Trans-Canada Airways, with its multitude of emergency landing fields, required many units. Modern warfare is power on wheels, and much of it is electric power dependent on small generating systems. Finally, industries, hospitals, and communications awoke to the necessity of stand-by power as an air-raid precaution.

Only the isolated single-generator system is considered in this article, as parallel operation in larger systems has received considerable attention elsewhere.

VOLTAGE-STABILITY PROBLEMS

The conditions giving rise to voltage-stability problems in small a-c generators may be divided into two general classifications, although these are not rigidly defined and verge into one another. Firstly, there is the problem of load changes, usually large and of comparatively long duration, of the order of one-half second and longer. This includes the starting of a-c motors and many types of welders. Sudden variations in the shaft load of motors already on the line should be considered also. Secondly, there is the problem of load pulsations, usually of smaller magnitude and of very short duration, of the order of $^1/_{20}$ or $^1/_{10}$ of a second. The pulsations may be caused by such loads as spot welders or a radiotelegraph key. These voltage changes may cause objectionable light flicker or a chirping noise in radio equipment.

A study of the voltage changes in small machines involves consideration of the voltage-regulator characteristics, the stator-winding resistance and inductance, the amortisseur-winding characteristics, the field characteristics, and the saturation of the a-c machine, as well as the stability or saturation of the exciter, its response rate, the regulator response, the stored kinetic energy in the rotating system, and the governor sensitivity, regulation, and response rate.

VOLTAGE REGULATORS

Over a period of years the vibrating-contact or Tirrell regulator was used so commonly that the word "Tirrell" became almost synonymous with voltage regulator. The maintenance cost for contacts was high. In small systems closely connected with radio equipment, the elimination of radio interference from the vibrating contact is difficult. To offset these difficulties the direct-acting rheostatic-type regulator was developed, where the voltage is distributed across numerous contacts in series connected across a resistance stack. Originally, these were slightly more sluggish than the Tirrell regulator because of static friction in the operating mechanism and the relatively high inertia of the armatures, although only rarely was this of any practical significance. However, modern regulators incorporate low-inertia armatures and frictionless spring mountings.

More recently there has been developed the exciter field-forcing-type regulator. These regulators effect a manifold increase in the exciter response rate by connecting to the exciter field a separate, controlled source of direct current which can be changed almost instantaneously. For example, if an exciter is operating at 60 volts, with 30 volts field *IR* drop, and the resistance of a rheostatic regulator is entirely cut out, 30 volts is available to operate against the inductance of the exciter field and to cause it to build up. A field-forcing-type regulator may raise the voltage on the exciter field to 250 volts, leaving 220 volts or an increase in rate of over seven times, to cause build-up. These regulators usually will impress a negative voltage, also, for building down. Armature-reaction-type generators, known as Amplidynes, have been developed, also, as small standardized motor generator sets for such service. These are rugged and provide the highest known ratio of amplification and power output for a given cost. Also, at extra cost, they may be used directly to excite the alternator.

Self-regulating generators, which are of two types, may be included here. Both actually tend to maintain constant flux rather than constant voltage, so that voltage varies at least as much as speed. In the first type the a-c flux is made to operate on the exciter flux in such a

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A. J. Girdwood is assistant engineer, a-c-d-c engineering department, Canadian General Electric Company, Peterboro, Ont., Canada.

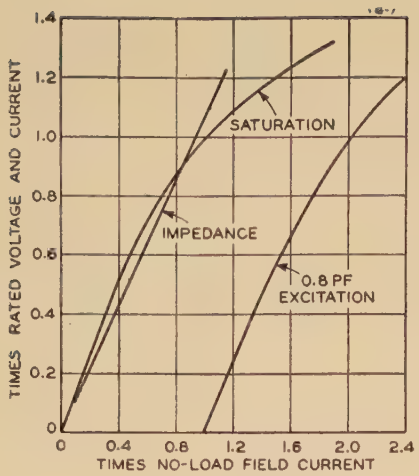


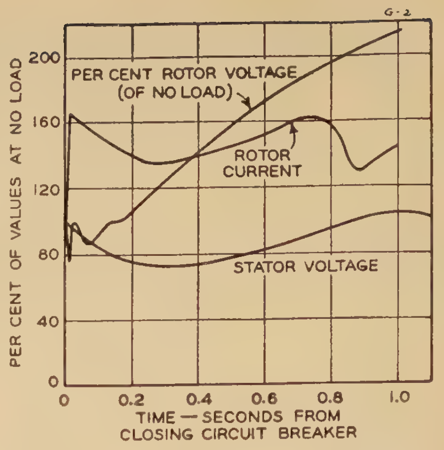
Figure 1. Typical saturation, impedance, and load excitation characteristics of a standard small a-c generator

way as to reduce it; this is achieved usually by using a revolving-armature a-c generator and extending some turns of the exciter-armature winding into the main generator armature. The operation is almost exactly the same as that of a standard machine with regulator except that the amplification factor of the regulator is lost. Sensitivity must be achieved by operating with a small degree of saturation in both main generator and exciter. Comparatively small voltages are available to overcome the inductance of the exciter field, so that when heavy loads are thrown off and on, voltage swings are apt to be severe and of long duration, although the settled voltage regulation may be very close. Such machines have found wide application for almost purely lighting loads on ranches, summer resorts, and exploration camp sites.

The second type is the so-called saturated-pole machine. In this type, the main generator is operated well up on its saturation curve. The proportions are changed from the standard type of machine so that flux densities in the armature teeth, where a large portion of the core loss occurs, are kept low. A reasonable degree of saturation should exist, also, in the exciter, so that its voltage will not collapse with reduction in speed in the prime mover. Such machines have, of course, a greater settled regulation than the former type, the usual guarantee being eight per cent. However, it should be remembered that for a given load the transient swing will lie inside the settled voltage limit, a factor of considerable importance in many applications. This desirable feature of low voltage-transient swings has made it advisable in some cases to apply saturated-pole machine with more or less standard exciters and voltage regulators. Sometimes, such an arrangement is an alternative to the use of a standard machine with a field-forcing-type regulator; the preference is usually based on economic reasons.

Figure 1 shows a saturation and impedance curve of a more or less standard machine. Figure 2 shows the variations in rotor current, rotor voltage, and armature voltage, with the machine under the control of a resistance-type direct-acting regulator, when an induction motor with an inrush 130 per cent of the generator rating is thrown on the line. The regulator used was not modern, and some slight delay occurred before the exciter voltage began to build up.

Figure 2. Voltage and current variations during the starting of an induction motor when connected directly to a generator with a resistance-type direct-acting regulator



Motor inrush current at 600 volts—41 amperes (130 per cent of generator rating)

Generator: 31 kva; 0.8 power factor; 1,800 rpm; 600 volts

Exciter: 1 kw; 1,800 rpm; 125 volts

Figure 3 shows the variation in generator output voltage of a machine under the control of an Amplidyne regulator. In this case, the speed of the machine was 1,200 rpm rather than 1,800 rpm, and its reactance was somewhat greater. The load thrown on was approximately rated load. It may be noted that the amount of voltage swing is less, but even more noteworthy is the short lapse of time until the voltage returns to normal—an interval so short as to be imperceptible for most applications. It is said that this performance can be improved.

Figure 4 shows the saturation and impedance curves of a particular saturated-pole machine, and Figure 5 the performance when the load is suddenly increased from half to full load. The time interval of return to normal is relatively long, but the amount of deviation is small. This arrangement finds particular application where part of the load is radiotelephone or telegraph equipment. The chirping noise is a function of the rate of change of voltage, and it may be noted that the rate

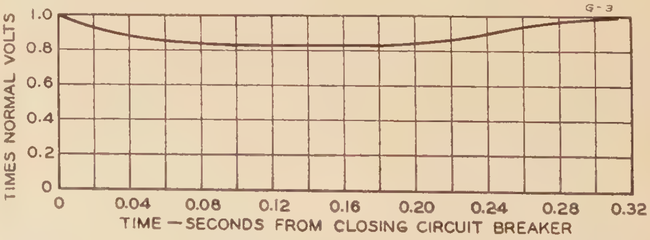


Figure 3. Output-voltage variation of standard a-c generator with Amplidyne regulator

Generator: 37.5 kva; 1,200 rpm

Load: 100 per cent rated load; 0.4 power factor

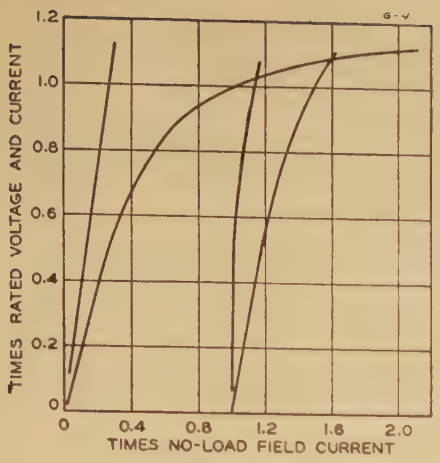


Figure 4. Typical saturation, impedance, and load excitation characteristics of saturated-pole small a-c generators

of change here is least. It must be remembered, however, that the usual requirement that the machine operate satisfactorily at ten per cent overvoltage and undervoltage must be foregone, and that the speed regulation of the prime mover must be within reasonable limits. The Amplidyne, and similar regulators with standard machines, will maintain voltage over a fairly wide speed range and will operate at overvoltage and undervoltage.

SPEED OF ROTATION

This article makes no effort to discuss the relative merits and economics of low- versus high-speed internal-combustion engines. However, the author believes that, even if one does concede the low-speed engine longer life and less vibration, there still have been many cases where unnecessarily low speeds have been used for stand-by service. Figure 6 shows the voltage deviation of a-c generators of various rotational speeds, when reactive loads of 75 per cent of the rating of the generators are applied. It may be seen that the momentary voltage dip of the high-speed generator is much less than that of the low-speed generator. This divergence in characteristics increases greatly as the kva rating of the generator decreases.

Figure 7 shows the variation in cost with speed, on a unit basis, of gasoline-engine-driven sets. The dashed line shows the relative cost of a 50-kw unit designed so that voltage will not fall below 70 per cent when an inductive load of 200 per cent of the rating of the generator is applied. The purchase of machines having

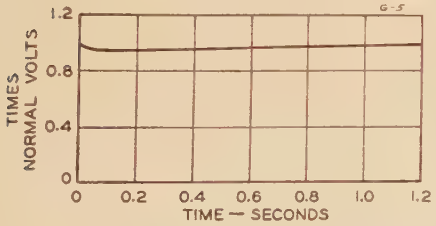


Figure 5. Output-voltage variation of saturated-pole small a-c generator with direct-acting rheostatic - type regulator

Generator: 31 kva; 1,200 rpm
Load: 100 per cent rated load; 0.4 power factor

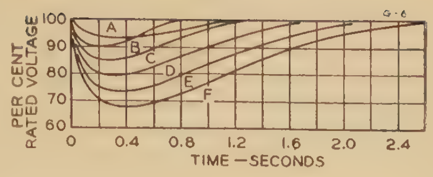


Figure 6. Calculated curves of terminal voltage of standard 63-kva a-c generators with direct - connected exciters when load is applied

Balanced three-phase zero-power-factor linear-impedance load equal to 75 per cent of the kva rating of the machine switched on; no original load
High-speed resistance-type direct-acting regulator
Constant rotational speed

A—3,600 rpm; 2 poles C—1,200 rpm; 6 poles E—720 rpm; 10 poles
B—1,800 rpm; 4 poles D—900 rpm; 8 poles F—600 rpm; 12 poles

unnecessarily low speeds of rotation can be seen to constitute a waste of vital war material and labor of a serious nature. Also, it should be noted here that the saturated-pole-type machine is economical only at reasonably high speeds—not less than 900 rpm at 94 kva and not less than 1,200 rpm at 12$^1/_2$ kva.

PRIME MOVER

The necessity for close speed regulation readily can be understood. Figure 8 illustrates how reduction in speed can cause complete collapse of exciter voltage. Any reduction in speed reduces the exciter response rate and its ceiling voltage.

Low-speed engines are equipped with large flywheels. High-speed internal-combustion engines do not require large flywheels, and the ratio of stored kinetic energy to rated power energy per second will probably be about 0.7 or 0.8 to 1. This low kinetic energy can be compensated by a rapid-response governor. One manufacturer, at least, claims full stroke in 0.02 second. An average rate probably would be start of stroke in 0.1 second, full stroke, 0.5 second. If full kilowatt load is thrown on a machine having a governor with these characteristics and a stored-kinetic-energy ratio of 0.8, the speed will fall for a transient period to an 80 per cent minimum.

The effect of temporary overload is more serious. Most internal-combustion engines have a rapidly drop-

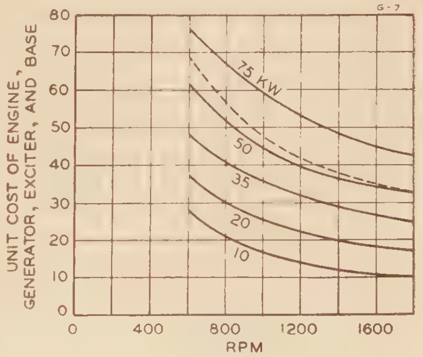


Figure 7. Approximate variation in cost with speed of gasoline - engine - driven a-c generator sets

Standard 0.8-power-factor generators rated for 50 degrees centigrade rise

Dashed line indicates a 50-kw machine designed so that starting an induction motor with inrush 200 per cent of the generator rating will not cause terminal voltage to drop below 70 per cent ping speed-torque curve at open throttle when the torque demand exceeds the rating. Fortunately, heavy overloads are usually largely reactive, and it is seldom that the kilowatt demand exceeds the rating.

LOAD

Tolerance of voltage variation differs considerably. Figure 9 shows the approximate amount of voltage variation giving objectionable lamp flicker. Sometimes it may be more economical to provide a small separate source for lighting than to design the main supply to avoid lamp flicker.

Spot-welding equipment requires fairly close voltage regulation to avoid spoiled welds. It is common to specify that voltage remain within plus or minus five per cent of normal. If more than one welder is used on a single generator in addition to the load cycle and characteristics of each welder, the permissible number of spoiled welds should be considered. In the case of a welder which is on 1/20th of the total time and there are five welders on a single machine, if four welders operating at once give good welds and five at once give spoiled welds, one in $20^5/5$ or one in 640,000 welds will be spoiled. It is seldom that this will justify a 25 per cent increase in capacity.

Undervoltage releases and a-c magnetic contactors on a-c motor starters usually may be adjusted to remain closed at a voltage as low as 50 per cent of rated voltage. However, they may require as much as 85 per cent of rated voltage to close, if the starting operation should require any contactor to close during the voltage dip. Any induction motors already on the line and carrying load will draw an increased current when the voltage is lowered, and may possibly stall if the voltage drops to 70 per cent.

Within these limitations it is necessary to have sufficient voltage at the motor to start it. Load starting-torque requirements vary from that just sufficient to overcome static friction to 175 or 200 per cent of rated torque for some applications under adverse conditions.

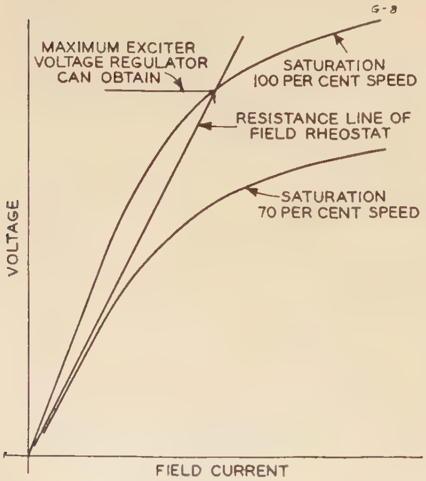


Figure 8. Diagram illustrating how reduction in speed of the prime mover can cause exciter voltage to collapse

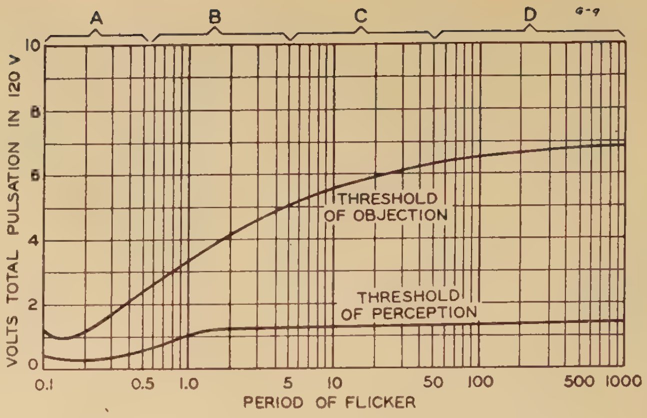


Figure 9. Voltage pulsations causing lamp flicker

A—Cyclic pulsations
- *Reciprocating pumps*
- *Compressors*
- *Automatic spot welders*

B—Low-frequency cyclic pulsations
- *Flashing signs*
- *Arc welders*
- *Manual spot welders*
- *Drop hammers*
- *Planers, saws, shears*
- *Group elevators*

C—Frequent noncyclic pulsations
- *Single elevators*
- *Hoists, cranes*
- *Wye-delta change on elevator motor-driven sets*
- *X-ray equipment*

D—Infrequent noncyclic pulsations
- *House pumps*
- *Sump pumps*
- *Air-conditioning equipment*
- *Theatrical lighting*
- *Domestic refrigerators*
- *Oil burners*

Starting torques developed by motors also vary with the type of motor as well as with the size and speed. Considering the load torque required as TL, and the full-voltage starting torque of the motor as TM, then $\sqrt{TL/TM}$ of full voltage will be required at the motor for a successful start. This determines the lowest voltage tap that may be used on a reduced-voltage or series-impedance-type starter, if the generator and exciter, under regulator control, is capable of returning to full voltage after the initial dip, carrying the inrush obtained. If it is not, the highest voltage to which it will return should be used in determining the tap. This calculation is one of trial and error, as the higher the tap, the higher the inrush and, therefore, the greater the voltage dip. When a proper solution has been reached, however, an estimate of the bottom of the voltage dip before recovery occurs should be made to see if it runs afoul of any previous limitations.

If the load to be started has low inertia, the motor may start and come sufficiently far up to speed that the motor current will have fallen considerably during transient conditions before the voltage reaches its lowest point. If the conditions are thoroughly understood, advantage may be taken of this fact, particularly on unregulated systems. Because the motor comes up to speed faster and the saturation effect is fully utilized, it is usually possible to start a larger motor from a given generating system on full voltage than on reduced voltage if the voltage dip is not objectionable.

The presence of other load or control devices may necessitate use of special starting equipment. The wound-rotor induction motor provides the best conditions, and by insertion of sufficient secondary resistance, almost ideal conditions may be obtained. It should be remembered, however, that the value of external resistance that gives the highest starting torque does not give the lowest inrush. When, therefore, a wound-rotor motor is used because of limited generating equipment rather than for speed control or for starting torque, as is usual, it is essential that the design of the generator, motor, and control be co-ordinated.

A compensator-type reduced-voltage starter with a squirrel-cage induction motor introduces a reactive magnetizing current of the order of 10 to 25 per cent of the starter rating in addition to the necessary inrush to the machine. Except for this addition, the inrush current is reduced in the same proportion as the torque. Thus, if the available starting torque of the motor is 150 per cent, if the inrush is 500 per cent at full voltage, and the load requires 50 per cent torque, the motor may be connected to a 60 per cent tap. Torque developed will be $(0.6)^2 \times 150 = 54$ per cent. Inrush will be $(0.6)^2 \times 500 + 25 = 180 + 25 = 205$ per cent of the motor's normal current.

Series resistance or reactance starters are commonly used. Often, while they can be used to advantage, it is only at a considerably reduced ratio of motor rating to generator rating. For example, a series resistor used to reduce the starting torque to the minimum permissible 50 per cent, would reduce the inrush to 290 per cent. As the resistor is a unity-power-factor device, the reactive current actually will be less than with a reduced-voltage starter by the amount of the magnetizing current of the autotransformer. The much higher in-phase current will have some effect, of course, but actually a motor started with a resistor will have very little more effect on the generator voltage, in most cases, than one with a reduced-voltage starter, provided there is no change in engine speed.

In the aforementioned example, a motor started by a compensator-type reduced-voltage starter would put a load on the engine of about 75 per cent or less of the rating of the motor to get a torque output of 50 per cent. A combined motor and resistor starter for the same starting torque would put a load on the engine around 270 per cent of the motor rating. It may be necessary, therefore, that the WR^2, or governor response, and the open-throttle speed–torque characteristics of the engine be co-ordinated to carry a considerable overload during the starting period of the motor.

With a series reactance starter, no extra load is placed on the engine above that obtained with a reduced-voltage starter. The reactive current is greater, however. In the example given, with a reduced-voltage starter there would be a reactive current of about 190 per cent of the rating of the motor, whereas with a reactor starter the reactive current would be about 280 per cent.

If either of these systems is feasible, the choice between the two will depend largely on generator and engine characteristics. In general, the reactor starter would be better on a high-speed machine where the transient reactance of the generator would probably be low and the stored kinetic energy of the engine would be low also. On relatively slower units probably a resistor starter would be better.

In extreme cases more expensive arrangements can be made. When the conditions are known, the motor manufacturer may be able to offer a machine having a somewhat higher ratio of starting torque to inrush than the best standard units. In such a case it is not advisable to ask for competitive estimates on low inrush, as this may result in sacrifice of more important characteristics. For example, a given rating may have an AIEE standard efficiency of 89 per cent. The manufacturer's regular line may average 90.5 per cent. If forced to give a competitive estimate on low inrush, he may decide to lower his efficiency margin. In some locations where fuel is expensive, the loss of one per cent efficiency on a 50-horsepower motor may cause a loss of approximately $100 a year which might have been avoided if the manufacturer had been asked merely to offer an effective solution to the whole problem.

Starters incorporating power-factor correcting devices such as capacitors in series or parallel have been proposed but I do not believe have been used to date. It is seldom that a cheaper satisfactory method cannot be found. However, they can be developed in case of necessity.

Series capacitors have been proposed to offset machine reactance for spot welding and similar duty. It would be necessary to protect against excessive overvoltages across the capacitor during short circuits or heavy overloads. So far the use of special-design overside generators has proved more economical.

LOAD PULSATIONS OF VERY SHORT DURATION

From the foregoing discussion it can be understood that when the load pulsation is of very short duration, in the order of two to eight or ten cycles per second, the best that any governor or voltage regulator could do is to maintain average speed and voltage. No one seems to expect that rapid pulsations in speed can be prevented by means of a governor. However, it does seem to be expected that rapid regulating systems can prevent voltage flicker of similar duration. This is true in spite of the fact that, in general, an internal-combustion engine will respond almost immediately after the throttle has been opened, whereas a definite time interval is necessary to build up the main flux linkage of the generator sufficiently to overcome even the transient reactance drop.

Assuming constant speed, therefore, it is necessary that the reactances be kept low enough to limit the voltage variation to the required amount, as practically no help can be expected from any regulating system. In fact, a regulating system having some lag is preferable as it would act only to correct average voltage. A fast regulator, on the other hand, by causing the exciter voltage to rise during load periods and therefore to be higher when the load is dropped and vice versa, is very apt to increase rather than reduce voltage variations. In other words, conditions may approach that shown in the lower part of Figure 10.

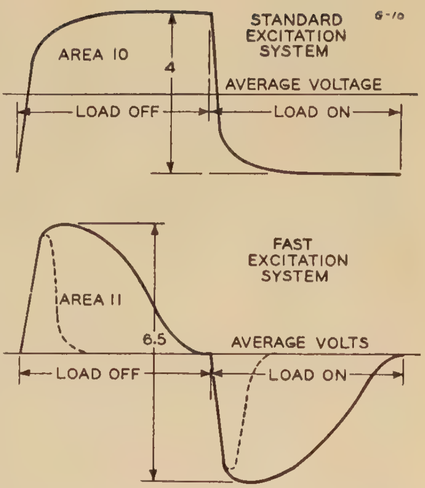


Figure 10. **Possible effect of keyed load on voltage of small a-c generators**

Slower regulation gives the effect, shown in the upper half of Figure 10, of having a considerably smaller voltage deviation from the average. A much faster excitation system might give the condition shown by the dotted line, but for many purposes even that will not be as satisfactory as the top half of the figure.

The purchaser of small generating equipment should consider carefully his reasons for specifying certain limits to voltage variation of short time duration. Naturally, the determination of these limits rests only with the user or manufacturer of the load equipment. The psychological factors of lamp flicker have been shown already. This is the most common limitation. Use of the curves should be made with judgment dependent on class of service as well as the duration and frequency of periods of disturbance. The limitation of five per cent high to five per cent low commonly required for spot-welding equipment has also been noted. Correct voltage is essential to the efficiency and life of resistance devices, and for emission of energy in one form or another. Where the voltage pulsation is fairly rapid, however, its effect may not be as severe as would be expected. For example, if t is the heating time constant of a resistance element, that is, the time to reach $(1-1/\epsilon)$ or 63.1 per cent of its final value, KE the overall voltage variation, and f the frequency of a complete cycle of variation in cycles per second, then the variation in temperature rise over the ambient will be

$$\frac{(1+k)^2-1}{1+(2nft)^2}$$

If for example, $K=0.05$, $f=10$, and $t=0.5$, temperature variation $=\frac{0.10}{1+31.4^2}=0.0032$, or about $^3/_{10}$ of one per cent. However, limitations other than actual temperature change may often appear, and as has been said, the type and degree of limitation can be determined only by the user or manufacturer of the load equipment.

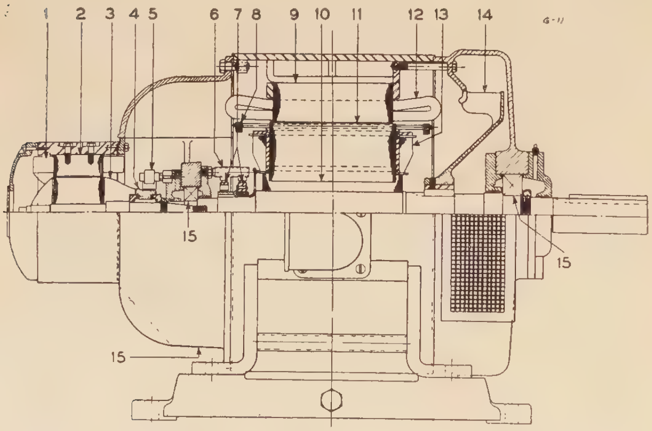


Figure 11. **Cross section of a typical synchronous machine of antifriction-bearing type with direct-connected exciter**

1—Exciter field coil
2—Exciter pole piece
3—Exciter armature coil
4—Exciter commutator
5—Brush yoke assembly
6—Brush holder stud
7—Collector rings
8—Starting winding
9—Stator punchings
10—Rotor-spider
11—Field-pole punchings
12—Stator coil
13—Field-coil winding
14—Fan
15—Bearing

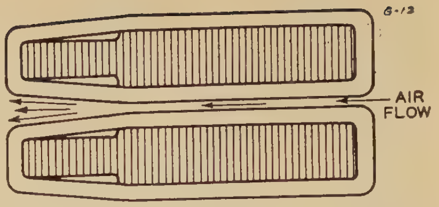


Figure 12. **Tapered pole construction for small a-c generators showing divergent nozzle effect of the air path through the interpolar space**

CONSTRUCTION AND DESIGN

The problem of arrangement of the parts of the small machine is largely one of economics, and differs with almost every manufacturer. The designer must lay out his machine in such a way as to utilize his previously accumulated experience and data. Above all else, he must rely largely on his existing machine tool, die, and pattern equipment.

A typical design is shown in Figure 11. The main feature is the use of revolving-field machines down to 6.3 kva at 1,800 rpm. The rotor-spider punchings are piled individually or in groups on the shaft with a press fit by means of a small press, and are keyed to it. The poles are retained by means of dovetails and keys. The pole insulating collars are usually cloth-base bakelite bonded. The coils are insulated from the pole body by means of high-temperature varnished cambric. The field-coil conductor is usually round copper Formex insulated to provide high dielectric strength at crossovers, high abrasion resistance, uniformity, good space factor, and good heat transfer. Bonding of the coil is accom-

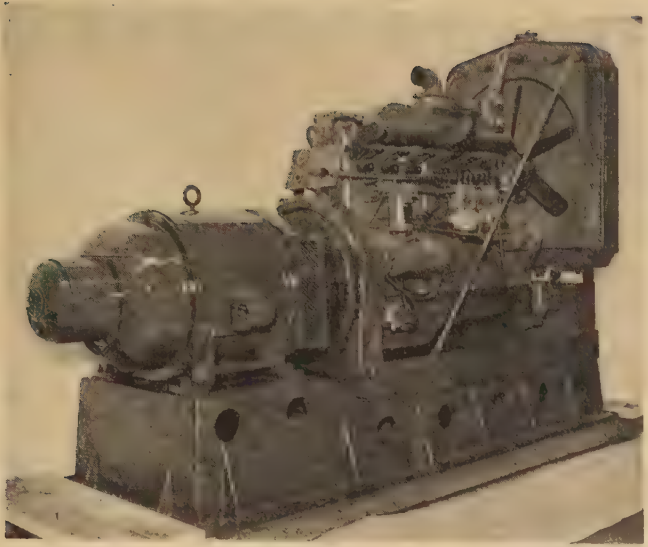


Figure 13. Typical gasoline-engine-driven generator set

Generator: 63 kva; 0.8 power factor; 1,200 rpm; 550 volts; three phase; 60 cycles

Engine: 135 horsepower

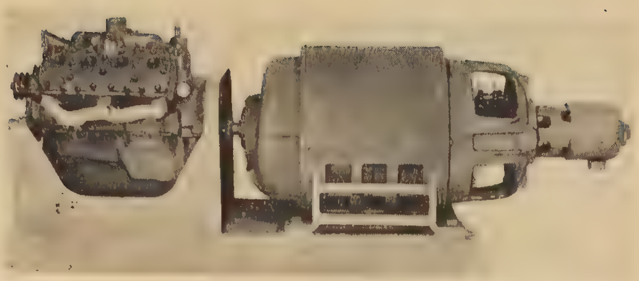


Figure 14. Two-pole generator directly connected to a Ford V-8 engine

Generator: 75 kva; 0.8 power factor; 3,600 rpm; 440 volts

plished by means of high-temperature low-solvent varnish, and the coil is baked under pressure for approximately 24 hours. Stator cores and frames are similar to standard induction motors. Collector rings are pressed onto cloth-base bakelite shells mounted on the shaft.

Up to sizes of the order of 300 kva at 1,200 rpm, these machines are single-end ventilated. This is so because the main limitation on the design of these machines is field-coil heating. Single-end ventilation cools the field coils more effectively and at the same time offers an opportunity to save material, weight, and space. By arranging the mounting, ventilation of the exciter and further economy of weight and space can be effected.

The collector-end end shield contains a barrier wall mounting the bearing. The exciter is mounted directly on the shield with the commutator next to the bearing. The exciter brush-holder yoke is mounted on the bearing cap. Ventilating air enters at the bottom of the shield beyond the barrier, and must pass up and over to enter the machine. The commutator and end portions of the machine are thus situated in a transverse stream of cooling air—the most effective means of cooling this type of machine yet discovered. While some air is allowed to pass outside the core between the core and the frame, the main body of ventilating air is directed through the *bore*, along the air gap, and between the field poles. Air also enters the outside end of the exciter, cooling the field coils. The upper part of the shield is removable, giving ready access to all brushes.

As mentioned before, field-coil cooling constitutes the main limitation to the design of a small compact unit. It is desirable, therefore, that the sides of the adjacent field coils should be reasonably parallel and fairly close together, as this is the best condition for heat transfer. An axial component of air velocity of 4,000 to 6,000 feet a minute between the poles is desirable both for effective heat transfer and to prevent the accumulation of dirt at this point. This represents a velocity head of between 1 and $2^{1}/_{4}$ inches of water. Very often this pressure head is not available in the fan, so it is essential that some of the velocity head be recovered.

Figure 12 shows how a divergent nozzle can recover a large part of the velocity head if the angle of divergence lies within fairly narrow limits, such as 10 to 15 degrees. The device is applicable in the field coils of a machine. A number of punchings at the fan or exhaust end are trimmed to a narrower width of pole body than the remainder. The field coil, when wound on a pole so constructed, forms an excellent divergent nozzle. It remains, then, to calculate the pressure drop in the system for an assumed air flow and then, based on the law that total pressure drop varies with the square of the air flow, to plot volume against pressure on the fan-characteristic curve sheet.

Once this figure is known, the scrubbing velocity of the air against various parts of the field structure can be estimated. The fact that the air in the gap has a rotational component relative to the pole face because of the drag of the stator bore should be noted.

The heat transfer from the various parts can be estimated next. As radiation is of the order of 0.004 watt per square inch per degree centigrade, its heat loss from any part not subjected to the air flow can be ignored safely. A heat-transfer circuit then can be set up. The addition of the air-temperature rise and an allowance for drop through the coil itself gives the field-temperature rise. In the instance illustrated, calculated rise was 49 degrees centigrade and the test rise was 52 degrees.

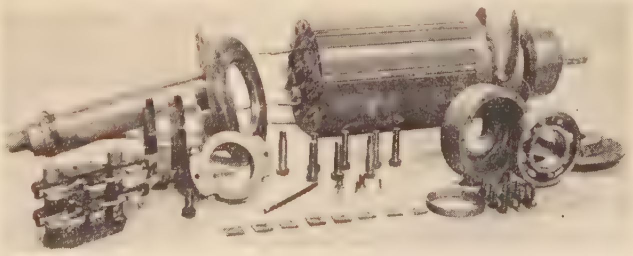


Figure 15. Rotor parts for the two-pole generator shown in Figure 14

INSTITUTE ACTIVITIES

Southern District Technical Meeting to Be Held at Roanoke, Va., November 16–18

A three-day technical meeting of the AIEE Southern District will be held in Roanoke, Va., November 16–18, 1943. The tentative technical program has been arranged to be of aid in the war effort. The four technical sessions tentatively scheduled deal with the following subjects: wartime operation, wartime development, special equipment, and power supply. In addition, there will be a general session opening the meeting on November 16, and two dinner meetings with specially invited guest speakers. A meeting of the District executive committee will be held at the conclusion of the opening session. Headquarters for the District meeting will be in the Hotel Roanoke.

REGISTRATION

Members who receive an advance registration card by mail should fill in and return the card promptly. This will save time on arrival at the meeting, as badges for advance registrants then can be prepared in advance. No registration fee will be charged for members, enrolled students, and the immediate families of members. There will be a $2.00 registration fee for all other nonmembers.

COMMITTEES

Those making arrangements for the meeting and the chairmen of subcommittees are: A. P. Gompf, *chairman;* E. S. Fitz, *vice-chairman;* W. I. Whitefield, *hotels and transportation;* Cecil Gray, *publicity and attendance;* R. C. Bailey, *technical papers;* Claudius Lee, *student activities;* C. L. Crosby, *finance.*

Tentative Technical Program

Tuesday, November 16

9:00 a.m. Registration

10:30 a.m. Opening Session

A. P. Gompf, presiding

Welcome: **Honorable Walter W. Wood,** mayor of Roanoke, Va.

Response: **C. W. Ricker,** vice-president, Southern District, AIEE

Address: **N. E. Funk,** president, AIEE

10:30 a.m. District Executive Committee Meeting

1:00 p.m. Executive Committee Luncheon

2:00 p.m. Wartime Operation

H. B. Wolf, presiding

DP.* The Effect of Kilovar Supply on Design of Systems for Load Growth. **T. W. Schroeder, J. W. Butler,** and **N. H. Meyers,** General Electric Company

DP.* The 13,500-Kva Static Capacitor Installation at Newport News. **E. L. Harder,** Westinghouse Electric and Manufacturing Company, and **V. R. Parrack,** Virginia Public Service Company

DP.* Capacitor Application in Pipe-Line Pumping Stations. **M. A. Hyde, Jr.,** Westinghouse Electric and Manufacturing Company

7:30 p.m. Dinner Meeting (Informal)

J. H. Berry, presiding

Guest speaker: Representative from Headquarters of the U. S. Armed Forces

Wednesday, November 17

9:30 a.m. Wartime Development

Stanley Warth, presiding

DP.* Growth of the Higgins Plant. **Milton L. Levy,** Higgins Industry, Inc.

DP.* High-Voltage Low-Pressure Gas-Filled Cable (illustrated by motion pictures). **W. A. Del Mar** and **A. F. Gambilla,** Phelps Dodge Copper Products Corporation, and **W. F. Nimmo,** Virginia Electric and Power Company

DP.* Training Program for Future Technicians. **Dean W. S. Rodman,** University of Virginia

2:00 p.m. Special Equipment

J. E. Housley, presiding

DP.* Modern Hydraulic Turbine Governor Design and Operating Characteristics. **C. L. Avery,** Woodward Governor Company

The above paper will be discussed by **C. L. Karr,** Tennessee Valley Authority

DP.* Design and Operation of Governor Control for Hydro Units. **J. F. Roberts,** Allis-Chalmers Manufacturing Company

C. P. Almon, Jr., Tennessee Valley Authority, will discuss the paper by J. F. Roberts

DP.* Design of Tie-Line Control Equipment. **S. B. Morehouse,** Leeds and Northrup Company

The above papers to be discussed by **J. T. Logan,** Georgia Power Company, and **A. J. Skaale,** Carolina Power and Light Company

DP.* Influence of New Material on Future Design. **R. C. Bergvall,** Westinghouse Electric and Manufacturing Company

2:00 p.m. Student Conference

Claudius Lee, presiding

7:30 p.m. Dinner Meeting (Informal)

E. W. O'Brien, presiding

Guest speaker: **E. H. Alexander,** General Electric Company, on "Electronics in Industry," followed by movie film

Thursday, November 18

9:30 a.m. Power Supply

A. S. Hoefflin, presiding

DP.* New Chesterfield Station. **C. C. Dodge,** Stone and Webster Engineering Corporation

DP.* Additional Power Supply, Hampton and Alexandria Stations. **G. M. Tatum,** Virginia Public Service Company, and **R. H. Boas,** Gilbert Associates, Inc.

DP.* The Paddy's Run Power Station of the Louisville Gas and Electric System. **M. S. Winstandley,** Louisville Gas and Electric Company

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*DP: District paper; no advance copies are available; not intended for publication in *Transactions.*

AIEE Employee Pension Plan Adopted by Board of Directors

A retirement system, which will provide a pension for all AIEE employees who reach 65 years of age after having completed at least 12 years of service, was adopted by the Institute's board of directors on August 4, 1943 (*EE, Sept. '43, p. 412*). The system also provides for disability income for employees who are at least 50 years old and who have completed 20 years of service in the Institute. Participation is optional for present employees of the Institute, but will be a condition of employment for all future employees. All present employees who choose to participate immediately will be entitled to a prior-service credit which will increase their benefits without any additional contribution on their part. Participation will be automatically terminated with termination of employment.

A retired employee will receive an annual income amounting to $1^1/_2$ per cent of average annual salary multiplied by the number of years of his service subsequent to establishment of the plan. Prior-service credit will entitle present employees who join the system to an additional pension amounting to a percentage (determined by the number of years of prior service) of the highest earned salary. Minimum retirement income will be $600 per year and the maximum $3,000 per year.

The system will be financed by joint contributions from the Institute and the employees. For the latter the contribution will be $4^1/_2$ per cent of earned salary. In addition, the Institute will deposit a preliminary lump sum to cover payments for service prior to the establishment of the system. If all present employees join the retirement system this will amount to $88,000.

Any compulsory contributions, premiums, or taxes, required from the employer by future insurance, workmen's compensation, or similar legislation will be met by reduction in the benefits payable under the system. Contributions of both employer and employees may be reduced to compensate for any payments required by such laws, or the board of trustees may arrange for such payments to be made from the retirement fund.

Administration of the system will be by a board of three trustees: a member of the board of directors, will represent that body; the second must be a Fellow of the Institute who is not a member of the board of directors; and the third will represent the employees. Members of the first board of trustees are: Past-President H. S. Osborne, representing the board of directors; H. H. Barnes (F '13); and National Secretary H. H. Henline, representing the employees.

National Technical Meeting Held in Salt Lake City, Utah, September 2–4

Five technical sessions and five technical conferences were held during the national technical meeting at Salt Lake City, Utah, September 2–4, 1943. The session on electrical equipment for military aircraft and the conferences on metallurgy and mining were principally related to the war effort. Approximately 200 persons attended the three-day meeting, which had headquarters in the Hotel Utah.

The meeting was opened by A. LeRoy Taylor (F '41), general chairman of the meeting committee. After a few words of greeting, he introduced the Honorable Herbert B. Maw, governor of Utah, who gave the official address of welcome.

President N. E. Funk also was introduced, and spoke briefly. He expressed the opinion that, as the sessions continued, members would find them well worth the time and effort. In the past some members had advocated curtailment of meetings, but in view of changing world conditions and the fact that so many members now find themselves in different kinds of work, Doctor Funk stated that more than ever the meetings serve as a valuable medium for the exchange of information.

At the conclusion of the opening meeting, a technical session on theory and machinery was held, with B. C. J. Wheatlake (A '16), manager of General Electric Company, Salt Lake City, presiding. Four technical papers were presented.

BUREAU OF MINES INSPECTION

In the afternoon of the opening day, the laboratories of the United States Bureau of Mines were inspected, where the microscopic and spectroscopic analyses of ore are made. In the chemistry laboratory the sonic flocculation of smoke was demonstrated, and in the mechanical laboratory demonstrations of tensile tests and torsional fatigue were seen.

ULTRAHIGH-FREQUENCY DEMONSTRATION

After the visit to the United States Bureau of Mines, the campus of the University of Utah was visited, and in the chemistry laboratory an ultrahigh-frequency demonstration was given by the students under the direction of Professors O. C. Haycock and L. D. Harris. The transmitter used was designed for a ten-centimeter wave, operating at 3,000,000,000 cycles per second. For laboratory work the importance of selecting a wave length small enough to be used with the apparatus was emphasized. By means of a radiation horn transmitter and parabolic receiver, two students with their backs to the audience, by turning both transmitter and receiver in synchronism, were able to pick up the location of a third student with a piece of copper screening at several different locations in the rear of the audience. It was also demonstrated how two specially designed transmitters, each using a different frequency note, could be used for the blind landing of airplanes. Questions were answered by Professors Harris and Haycock.

CONFERENCE ON ELECTRONICS AND COMMUNICATION

The conference on electronics and communication was held Thursday evening, with Professor A. L. Albert (F '41), electrical-engineering department, Purdue University, presiding. Preceding the presentation of scheduled conference papers, President Funk was introduced. He gave an interesting historical summary of the development of electricity from the time of its discovery to the present, showing how slow early progress was and how rapidly developments have progressed in the last few decades. In concluding he said that no one should worry about the new frontiers or possibilities after the war, but, instead, everyone should devote the utmost energy toward his work.

An address "Electronics—A Tool for Industry" was delivered by R. H. Rogers of the General Electric Company, Salt Lake City, and illustrated with lantern slides. Mr. Rogers described the fundamental characteristics of the five or six different kinds of electronic tubes and the fundamental circuits employed. He explained that $^{1}/_{25}$ to $^{1}/_{35}$ of a second is the time required for a magnetic contactor to operate, whereas an electronic contactor operates in $^{1}/_{10,000}$ of a second. The high speed of operation permits many valuable applications without wear and pitting of contacts, as in the printing of cement bags, where the paper is traveling at a rate of 600 feet per minute. Another interesting application is the automatic leveling of the platform of a large crane-type shovel by electronic means.

Analysis of Registration at 1943 Pacific Coast National Technical Meeting

Classification	District 9	District 8	District 10	Miscellaneous	Totals
Members	78	34		34	146
Men guests	17	4		13	34
Women guests	11	2			13
Totals	106	40	—	47	193

Registration at Pacific Coast Technical Meetings—1933–1943

Year	Location	Registration
1943	**Salt Lake City, Utah**	**193**
1942	Vancouver, B. C.	245
1941	Yellowstone Park	322
1940	Los Angeles, Calif.	465
1939	San Francisco, Calif.	*
1938	Portland, Ore.	454
1937	Spokane, Wash.	266
1936	Pasadena, Calif.	*
1935	Seattle, Wash.	269
1934	Salt Lake City, Utah	232
1933	(No Pacific Coast convention)	

* Combined with summer convention.

Following Mr. Rogers' address E. V. Potter explained several uses of electronics in metallurgical research.

Other conference presentations in this session applied to the field of communication. F. A. Cowan (M '29) transmission engineer with the American Telephone and Telegraph Company, New York, N. Y., L. N. Schindel (A '36), Mountain States Division, Denver, Colo., and J. E. Heller (M '38), Pacific Telephone and Telegraph Company, San Francisco, Calif., described the protective devices and circuit protection against lightning employed on a transcontinental toll cable. The effects of lightning are reduced by providing conductive paths surrounding the telephone plant with a sheath having good conduction; protectors bleed off overvoltages. Mr. Heller explained that lightning is not particularly severe in the Pacific Northwest but that nevertheless lightning-rod protection and ground rods had been installed. In conclusion he stated that five other important routes were available, assuring continuity of service.

After the presentations Professor Albert conducted a round-table conference on the methods of teaching communication and ultrahigh frequency. Most of the discussion considered whether highly specialized subjects should be taught or whether more time should be devoted to fundamentals. It was recognized that a thorough grounding in fundamentals is essential for the students, but it also was considered necessary to train them along specialized lines so that they might obtain employment in their respective localities after graduation. The importance of teaching English also was discussed.

CONFERENCE FOR STUDENTS, COUNSELORS, AND OFFICERS

Approximately 40 attended the luncheon conference for students, Branch counselors, and national officers, held Friday noon in the Sea Gull Room of the Temple Square Hotel. President Funk addressed the luncheon and explained that he saw no reason to be disturbed about conditions in the postwar period, if engineers would devote all their energies to their work and show some degree of human intelligence. Laziness would prevent putting into effect their ideas as quickly as possible. To indicate the significance of existing developments, President Funk pointed out that during his early experience in the electrical industry the radio and telephone did not exist and the first electric lamps were just coming into being. He again brought to attention the rapid strides in recent years, and by way of illustration he cited that present developments in the ultra-high-frequency field would have been considered impossible 30 years ago. He said that in the next 50 years there would be no limit to the possibilities open to engineers.

National Secretary H. H. Henline, who was present at the first conference on student activities, held in Salt Lake City in 1926, addressed the luncheon meeting on the organization and work of the Student Branches. Organized to give the students opportunities to come into contact with older members of the Institute, the first Branch came into existence in 1902. Today the number of Branches totals 125. Mr. Henline further explained that the plan for organizing the Institute into Districts was put into effect in 1920, and he gave the date of establishment and the location of each Branch in the Pacific and Northwest Districts. In conclusion, he urged counselors and students to continue their activities as effectively as possible during present times, so as to be ready to resume normal activities after the war. He urged those who were able, to follow up Branch work by showing an interest in Section and national meeting activities.

Professor R. E. Lindblom (M '35) chairman of the committee on student activities in the Northwest District, presided over the meeting. Other speakers included Vice-President E. W. Schilling (M '33), Vice-President L. A. Bingham (M '39), and Professor F. W. Maxstadt (M '26) chairman of the committee on student activities in the Pacific District.

CONFERENCES ON METALLURGY AND MINING

These conferences were arranged as aids in the war effort to give engineers in general a better understanding of the problems involved in mining and metallurgy. The electrical industry is one of the largest users of copper, and a first-hand knowledge of the industry should aid in the conservation of this critical material. In the first conference, the physical aspects and the electrical properties of copper and copper alloys were described by P. H. Brace, Westinghouse Electric and Manufacturing Company. Metallurgical problems arising from the use of copper in electrical equipment were discussed in another paper prepared by E. R. Parker, General Electric Company, and presented by F. A. Compton, Jr. (A '39). "Metallurgy Production of Ferroalloys in Western States," "Production of Light Metals," and "Quantitative Spectrographic Analysis" were presented, respectively, by S. F. Ravitz, H. W. St. Clair, and G. W. Marks, of the United States Bureau of Mines, Salt Lake City. Vice-President E. W. Schilling presided.

In the conference on mining, held Saturday morning, and presided over by Doctor H. T. Plumb, technical-program chairman of the meeting committee, several conference papers were given. Historical and statistical data on copper mining throughout the world, as well as a description of the Open Pit Mine of the Utah Copper Company, Bingham, were presented by Robert S. Lewis, professor of mining at the University of Utah, Salt Lake City. The process of copper smelting at the Garfield plant of the American Smelting and Refining Company was described by W. G. Rouillard, superintendent of the Garfield smelter, and the uses of electricity in the mining and milling of copper were outlined by R. J. Corfield (M '41), electrical engineer, Utah Copper Company, Garfield.

In the afternoon a number of members went on the inspection trip to the Open Pit Mine at Bingham, where blasting operations were in progress. Operations at the pit were explained over a loud-speaker system to the party by Lewis Buckman, superintendent of mines, and R. J. Corfield.

ORGAN RECITAL

Friday noon a number of the members and guests attended a special organ recital in the Mormon Tabernacle, given by Alexander Schreiner, tabernacle organist, who illustrated the unusual features of the organ. The acoustic properties of the tabernacle were demonstrated also by the dropping of a pin, the sound of which could be heard distinctly at the far end of the structure.

Friday evening members and guests attended a get-together dinner at Maxfield Lodge in Big Cottonwood Canyon. After dinner an illustrated lecture, "Exploring Your Back Yard," was given by Professor R. E. Marsell of the department of geology, University of Utah. Professor Marsell's subject dealt with the geology of the Bonneville Basin from the early stages of "tillite," the deposit from an ancient glacier. He explained that originally the Bonneville Basin contained a fresh water lake approximately equal in area to that of Lake Michigan, which over hundreds of years has receded to the present Great Salt Lake, and which has retained the mineral deposits from the larger body of water.

Pamphlet on Emergency Rating of Power Cables Now Available

The nine conference papers on the emergency rating of power cables presented at the cable conference during the AIEE national technical meeting last January in New York, N. Y., have been assembled and reproduced in single pamphlet form for distribution. Copies of this pamphlet, AIEE Special Publication 6, may be obtained from Institute headquarters, 33 West 39th St., New York 18, N. Y., at 75 cents per copy. A 20 per cent discount will be allowed on orders of ten or more sent to one address at the same time.

These papers report that several of the country's largest power utilities have raised their normal operating temperature on power cables above industry standards after having conducted investigations on the deterioration of insulation, the mechanical effects of such increases, and recognition of an increase in the rate of cable failure. The general consensus of opinion is that it is safe to operate cables at emergency loadings equivalent to operating temperatures 10 to 20 degrees centigrade above present normal temperatures without shortening too greatly the life of the cable.

Brief abstracts of the papers follow.

Cable Application for Maximum Conservation; *G. L. Carlisle, War Production Board.* This paper sets forth the conditions under which the power branch of the War Production Board reviews applications for the purchase of power cables, and cites the factors which must be satisfied as to the ability of the utility to meet the situation before permission is granted to purchase.

Emergency Overloading Policies for Power Cables; *H. W. Collins (A '22), Detroit (Ill.) Edison Company.* This paper refers to a study made on the overloading of three-conductor, belted and shielded 24-kv paper cables in ducts as high as 140 to 150 degrees centigrade to meet the emergency ratings of transformers to which they were connected. Some of the cables failed near the end of the emergency load cycles, others appeared to be near failure, and the remainder not appreciably affected. There was no difference in results for new cables and some nearly 20 years old. It was finally decided to limit copper temperature to 110 degrees centigrade on the basis that emergency loading would not occur more often than once in every five years. If the frequency of emergency loading occurs as often as once a year, then the maximum emergency temperature allowable is 95 degrees centigrade. It is recognized that if the cable is to be operated at emergency loadings, adequate provision for expansion must be provided in the manhole design, and there is the possibility of split sheaths if these high loads are suddenly applied to new cable that has not been seasoned.

Cable Overloading, Its Effects and Possibilities as a Wartime Expedient; *H. L. Davis, Jr. (A '27) and C. S. Schifreen (A '26) special investigation section, Philadelphia (Pa.)*

Electric Company. Reasons for increasing the loading on a cable and what careful consideration must be given to the subject before executing it are discussed herein. An interesting report is given on the experiences of their company on increase of loading on 13-kv and 66-kv cable systems. On a group of 13-kv cables which carried emergency loads, the failure rate was nearly four times the rate prior to the time of overloading and about seven times the average for the entire system. Later, when this same group carried its normal load, the failure rate was nearly two and one half times that which it was originally and six times the average rate for the entire system. Examination of the failures indicated that they were mostly from lead sheath cracks which developed due to cable movement; about 40 per cent of the total number of lengths in the group had sheath defects. On the 66-kv system a comparison was made of the failure rate on a Group "C" with a Group "D." Group "C" operated with short-circuited sheaths and Group "D" with open-circuited sheaths. The conductor temperature on Group "C" was 69 degrees centigrade and sheath 55 degrees centigrade; on Group "D" 63 degrees centigrade and 50 degrees centigrade respectively. Originally when both groups were operated below AEIC temperature, that is 60 degrees centigrade, they had the same failure rate. When during 1930–1932 Group "C" was overloaded, its total trouble rate was seven and one half times that for Group "D" and two and one half times that for the system. Later when Group "C" was changed over to open-circuit operation the failure rate dropped to one fifth of that during 1930–1932 but remained three times that for Group "D." The major cause of failure was bursting of the lead sheaths from excessive internal pressure.

Practical Wartime Cable Operation; *G. E. Dean (A '28) Public Service Electric and Gas Company, Newark, N. J.* This company rates three-conductor belted 13-kv cables at 75 degrees centigrade for cables installed prior to 1920 and 80 degrees centigrade for cables installed since 1920. The AEIC value for temperature is 77 degrees centigrade for 26-kv belted cables; 57 degrees centigrade is used for cables installed prior to 1920, 62 degrees centigrade for 1920–1924 cables, and 67 degrees centigrade for cables installed since 1924. The AEIC value for temperature is 64 degrees centigrade. For 26-kv shielded cables, 75 degrees centigrade is used for cables installed prior to 1930 and 80 degrees centigrade for cables installed since 1930. The AEIC value for temperature is 74 degrees centigrade. The variations due to vintage are the result of changes in the nature of cable insulation and because in general the older cables are installed in cramped conduit systems without adequate expansion facilities.

Problems Arising in the Emergency Loading of Cables as Viewed by a Manufacturer's Engineer; *W. A. Del Mar (F '20) Habirshaw Cable and Wire division, Phelps Dodge Copper Products Corporation.* Herein are reviewed the influence which thermal resistivity of insulation, thermal emissivity of the sheath, and cables in ducts buried in the ground or in the air have on the current-carrying capacity of a cable. Explanation was given for limiting conductor temperature to 85 degrees centigrade, with reference to the hot spot along the circuit which usually is not easily located. Therefore, as in the cases of other electrical equipment, a maximum temperature which will not cause deterioration of the insulation is necessary for this hot spot and a deduction must be made for those locations at which the temperature can be determined and which invariably will be lower than the hot spot. Mr. Del Mar thinks that cables which operate over the present maximum operating temperature are living on "borrowed time" and that their ultimate life is decreased. This should be considered when setting up emergency ratings and the question "can we afford to do so" must be answered.

Use of Cable in Wartime; *Herman Halperin (M '26), Commonwealth Edison Company, Chicago, Ill.* Mr. Halperin refers to previous papers presented by him before AIEE, and in particular, his paper "Load Ratings of Cable—II," presented before the AIEE convention in June 1942. He repeats again the following statement in the June 1942 paper which is worth consideration by all interested in cable loading. "As a general proposition, one cannot be dogmatic about the allowable temperatures for a given underground cable circuit. Factors affecting the decision include age and condition of the cable and accessories, effect of heat on the properties of the materials in the circuit, magnitude of usual daily temperature range, size of manhole and training of cable therein, frequency of emergency loading, past history of loading of cable, relation of temperature and temperature range for normal loading to temperature and temperature range for emergency loading, number of cables in conduit, allowable conduit temperatures, thoroughness of field inspection and maintenance work, desired life of the underground circuit, and desired reliability of service. One factor or set of factors may allow one loading while another factor or set of factors for the same cable may allow less loading." Mr. Halperin's company has established maximum allowable operating temperatures for impregnated-paper-insulated cables operating at various voltages, which are tabulated in this paper.

Wartime Loading of Insulated Power Cables; *G. B. Shanklin (M '29), General Electric Company, Schenectady, N. Y.* Various ways to conserve copper in insulated wire and cable circuits are discussed. Reference is made to the effect of exceeding the standard temperature limits, stating that for each five to ten degree centigrade increase in normal daily load temperature, there is approximately a reduction of 50 per cent in the life of the cable insulation and double that in the failure rate. Tables giving suggested peacetime and wartime loadings for both normal and emergency operation for impregnated-paper-, varnished-cambric- and rubber-insulated cables are included. The paper also gives a table of 60-cycle short-circuit currents of 1.0-second duration for various conductor sizes and temperature rises above operating temperature.

Future AIEE Meetings

Southern District Meeting
Roanoke, Va., November 16–18, 1943

National Technical Meeting
New York, N. Y., January 24–28, 1944

National Technical Meeting
St. Louis, Mo., June 26–30, 1944

Cable Loading for Normal and Emergency Conditions; *C. T. Hatcher (M '37), Consolidated Edison Company of New York, N. Y., Inc.* Normal and emergency ratings are determined on the basis of maximum loading on the feeder in question, and on the basis that other feeders will not be loaded up to their rating. The upper temperature used for emergency ratings of high-voltage paper-insulated cables are based on the results of laboratory and field tests made during 1934 to 1937. It was concluded that 100 degrees centigrade is the maximum safe operating copper temperature for paper cables. Varnished-cambric cables are not operated over the IPCEA limits because of lack of data on the aging characteristics of this type of insulation. In cases of extreme emergency, such as the loss of a generating station, or the shutdown of a network area, feeder loadings, of necessity, have been allowed to exceed the emergency ratings, apparently with no marked increase in failure rates. Emergencies of this nature, however, occur very infrequently. The failure rate on the system has not increased nor has there been a noticeable deteriorationof insulation due to overheating since the above ratings have been used.

Mechanical Effect of Temperature Change in Lead-Covered Cables; *E. W. Oesterrich (A '42), Duquesne Light Company, Pittsburgh, Pa.* Mr. Oesterrich discusses the policy of "economy of plenty" during the prewar era to the "economy of scarcity" policy prevailing now, and how each factor concerned in the load rating of a cable must be considered. He refers to the recognition of the reduction in life expectancy and service reliability under present day conditions of availability of critical materials and equipment manufacturing production capacity.

An interesting description of studies made to reduce the number of sheath failures due to cable movement both from normal and emergency loadings is included, from which these conclusions are drawn:

1. Field surveys indicate that, theoretically, possible cable elongation under given operating temperatures

is only developed in a few isolated locations on the system.

2. The use of certain types of fireproofing material and the elimination of friction points in the manhole cable supporting structure will minimize the formation of stress-concentration areas and thereby will increase the life expectancy of the cable sheath.

3. Life expectancy of cable sheaths on cables now in service in certain types of manholes can be increased to a point where other conditions supply the emergency-rating limitation. Rehabilitation or improvement when required can be accomplished without the use of materials on the critical list at present.

SECTION • • • • •

Special Committee on Sections Manual Created

A special committee has been appointed to prepare a manual on Section operation and management for distribution to AIEE Section officers. The new committee was authorized by the board of directors at its meeting of June 24 in Cleveland, Ohio, when it approved a resolution passed by the Sections delegates attending the summer national technical meeting.

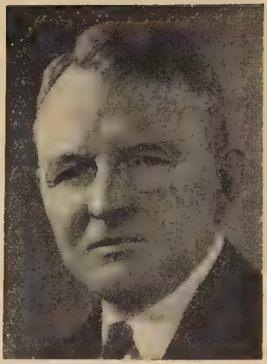
The resolution provided that two substantially bound copies of such a manual, covering all pertinent features of Section operation, such as duties of officers, suggestions of national committees, and other material assembled for ready reference, should be supplied by headquarters to each Section, one copy to be maintained by the chairman and one by the secretary. It provided further that the manual be arranged by numbered subjects in loose-leaf form to facilitate revision, and that it be passed on to incoming officers to assist them in their work.

Members of the new committee, appointed by President N. E. Funk, are: G. W. Bower and O. C. Brill, representatives of the Sections committee; John Mills and S. B. Williams, publication committee; M. D. Hooven and Robin Beach, technical program committee; J. H. Pilkington and E. P. Yerkes, membership committee; and H. E. Farrer and F. A. Lewis, headquarters staff representatives.

PERSONAL • • • •

C. L. Dawes

W. B. Kouwenhoven



W. R. Smith

W. B. Kouwenhoven (A '06, F '34) dean of the school of engineering, Johns Hopkins University, Baltimore, Md., has been appointed chairman of the AIEE Edison Medal committee for 1943–44. He served on that committee for 1935–37 and more recently has been a member since 1939. Doctor Kouwenhoven, who was born in Brooklyn, N. Y., January 13, 1886, received from Brooklyn Polytechnic Institute the degrees of electrical engineer in 1906 and mechanical engineer, *summa cum laude*, in 1907. In 1913 he earned a diploma in engineering, *summa cum laude*, from the Karlsruhe Technische Hochschule, Baden, Germany, and in 1914 the degree of doctor of engineering, *magna cum laude*. From 1907 to 1910 he was on the faculty of Brooklyn Polytechnic Institute: as assistant in physics until 1907, and as instructor in physics and electrical engineering thereafter. During 1913–14 he was instructor in electrical engineering at Washington University, St. Louis, Mo. In 1914 he joined the staff of Johns Hopkins University as instructor in electrical engineering. He was made associate in electrical engineering in 1917. On leave of absence from the University during 1919–20, he was employed as engineering superintendent at the Winchester Repeating Arms Company, New Haven, Conn. He resumed his duties at the university as associate professor in 1920 and was appointed professor of electrical engineering and assistant dean of the school of engineering in 1930. In 1938 he became dean of the school of engineering. He has been consulting engineer to the United States Bureau of Mines and the United States Bureau of Standards. Author of numerous papers, he was especially honored for two of them by the International Electrical Congress in 1932 and by the Resistance Welders Manufacturers' Association in 1942. His many AIEE activities have included the offices of chairman of the Baltimore Section in 1930 and counselor of the Johns Hopkins University Branch from 1938 to 1941, and membership on the following committees: instruments and measurements, 1925–41 (chairman, 1933–36); Sections, 1925–34 (chairman, 1927–30); research, 1933–41 (chairman, 1936–38); Lamme Medal, 1938–41 (chairman 1939–41); telegraphy and telephony (now communication), 1919–20; electrophysics (now basic science), 1924–33; co-ordination of Institute activities, 1927–30; safety, 1933–43; electrochemistry and electrometallurgy, 1935–42 (chairman, 1941–43); award of Institute prizes, 1936–38; standards, 1940–43; Institute policy, 1940–42, application of electricity to therapeutics, 1941–43; technical program, 1931–38, 1941–43. Doctor Kouwenhoven served as vice-president of the Institute for 1931–33 and as a director for 1935–39.

W. R. Smith (M '18, F '30) safety engineer, Public Service Electric and Gas Company, Newark, N. J., has been appointed 1943–44 chairman of the AIEE committee on safety of which he has been a member since 1939. He was born in Charleston, S. C., February 23, 1885, and was graduated from Clemson Agricultural and Mechanical College in 1906 with the degree of bachelor of science in electrical engineering. In 1928 he received the degree of electrical engineer. During 1907 he was employed as secretary and assistant to the head of the engineering department at Clemson college. In 1908 he entered the employ of the Hartford Suspension Company, Jersey City, N. J., as draftsman. In 1909 he became manager of the company's New England offices, Boston, Mass., and in 1911 of its Newark office. In 1912 he was placed in charge of the department of design at Jersey City. During 1913 he was salesman for the White Motor Car Company, Newark. He commenced his association with the Public Service Company in 1914 in the electrical construction department. From 1917 to 1922 he was field engineer in charge of construction work. With the formation of the Public Service Production Company, Newark, in 1922 he became superintendent of electrical construction and in 1924 was appointed managing electrical engineer. In 1927 he was made assistant chief engineer. He held the latter position with the Newark branch of the United Engineers and Constructors, Inc., from 1928 to 1935. In 1938 he returned, as transmission construction engineer, to the Public Service Electric and Gas Company. Since 1938 he has been safety engineer. He is currently (1942–46) serving as a director of the Institute. He has been active on the following committees: publication, 1935–36; co-ordination of Institute activities, 1935–37; Alfred Noble Prize, 1936–37; finance, 1942–43; board of examiners, 1930–36 (chairman, 1934, 1936); technical program, 1935–37 (chairman 1935–36); award of Institute prizes, 1935–37 (chairman, 1935–36). In addition he was chairman of the New York Section for 1934–35, and secretary for 1932–33. He holds membership in the National Society of Professional Engineers, the Edison Electric Institute, the American Standards Association, the American Society of Safety Engineers, and the National Safety Council.

C. L. Dawes (A '12, F '35) associate professor of electrical engineering, Harvard University, Cambridge, Mass., has been appointed chairman of the AIEE committee on instruments and measurements for 1943–44. He has been a member of the committee since 1939. Professor Dawes was born November 13, 1886, at Somerville, Mass., and was graduated from Massachusetts Institute of Technology with the degree of bachelor of science in 1909. As a member of the staff of the Massachusetts Institute of Technology, Cambridge, he was assistant in physics in 1909, and assistant in electrical engineering in 1910. From 1911 to 1916 he was instructor in the graduate school of applied science, Harvard University. Securing a leave of absence in 1913 and 1914, he served as professor of electrical engineering in the postgraduate school of the United States Naval Academy, Annapolis, Md. From 1916 to 1919 he was instructor in electrical engineering at Harvard University and the Massachusetts Institute of Technology. In 1919 he became assistant professor of electrical engineering, graduate school of engineering, Harvard University, and in 1931 was made associate professor. He has been awarded Institute best paper prizes for several of his numerous technical papers and is the author of engineering textbooks as well. His research work has been chiefly in the field of insulation. A number of patents have been issued in his name. In addition to his teaching career, he has acted as consulting engineer for many manufacturing firms including: Simplex Wire and Cable Company, Cambridge, the New England Mica Company, Waltham, Mass., and the Albert and J. Manders Company, Boston, Mass. Besides serving as Institute vice-president for 1938–40, he has been a member of the following Institute committees: membership, 1936–38, Edison Medal, 1938–40, Lamme Medal, 1942–45, and technical program, 1942–43. He is also a fellow of the American Association for the Advancement of Science, and a member of the Society for the Promotion of Engineering Education and the American Association of University Professors.

H. A. Affel (A '18, F '41) assistant director of transmission development, systems development department, Bell Telephone Laboratories, New York, N. Y., has been appointed 1943–44 chairman of the AIEE committee on communication of which he has been a member since 1938. Born August 4, 1893, in Brooklyn, N. Y., he was graduated from the Massachusetts Institute of Technology with the degree of bachelor of science in 1914. He was employed from 1914 to 1916 as research assistant on telephone receiving circuits and high-voltage transmission in the department of engineering, Massachusetts Institute of Technology, Cambridge, Mass. He entered the American Telephone and Telegraph Company, New York, N. Y., in 1916 where he engaged in development work on multiplex telephone and telegraph systems. In 1919 he became a group head in the department of development and research in charge of carrier telephone and telegraph development work. From 1930 to 1934 he supervised work on problems connected with transmission development of carrier telephone systems. In the same capacity he was attached to the staff of Bell Telephone Laboratories in 1934. He was made toll transmission development director in 1935 and assistant director of transmission development transmission development department in 1938. In 1940 he was transferred to the systems development department. For two of his numerous technical papers he has received honorable mention in the Institute's national best paper prize awards. He was honored as a modern pioneer at the National Association of Manufacturers' celebration of the 150th anniversary of the United States patent system in 1940. He is also a member of the Institute of Radio Engineers, the Acoustical Society of America, and the American Association for the Advancement of Science.

W. C. Kalb (A '13, F '40) commercial engineer, carbon sales division, National Carbon Company, Cleveland Ohio, has been appointed chairman of the AIEE committee on the production and application of light for 1943–44. He has been a member of this committee since 1929. Born in Arcadia, Ohio, September 3, 1882, he was graduated from Ohio State University with the degree of mechanical engineer in electrical engineering in 1904. From 1904 to 1907 he was employed by the Columbus (Ohio) Pneumatic Tool Company as a mechanical engineer. He entered the employ of the National Carbon Company as electrical engineer in 1907. During 1910–11 he was general superintendent of Dunlap Engineering Company, Columbus. Returning to the National Carbon Company in 1911, he became assistant foreman and in 1913 he was made sales engineer. As managing engineer he joined the Corliss Carbon Company, Bradford, Pa., in 1919 and in 1920 became general manager. When the Corliss company was purchased by the National Carbon Company in 1926, he remained superintendent of the Corliss plant. In 1927 he was transferred to the carbon sales division of the company, responsible for automotive brush sales. Placed in charge of technical publicity in 1928, he became commercial engineer in 1940. He holds various patents on brushes and brush shunts and has published many technical articles. Mr. Kalb was chairman of the Cleveland Section for 1938–39 and for 1941–42 and Section secretary for 1936–37. He has been a member of the following committees: industrial and domestic power, 1918–22; electrochemistry and electrometallurgy, 1931–43 (chairman 1932–34); and technical program, 1932–34.

W. C. Kalb

W. A. Lewis

H. A. Affel

W. A. Lewis (A '27, M '39) director, school of electrical engineering, Cornell University, Ithaca, N. Y., has been appointed 1943–44 chairman of the AIEE committee on research of which he has been a member since 1941. He was born January 21, 1904, in Harriman, Tenn. Attending the California Institute of Technology on a Westinghouse scholarship, he received the degrees of bachelor of science in 1926, master of science in 1927, and doctor of philosophy, *summa cum laude*, in 1929. From 1920 to 1922 he was switchboard engineer with the Westinghouse Electric and Manufacturing Company, Los Angeles, Calif. As a graduate student he held the position of engineer in the wiring department of the California Institute of Technology, Pasadena. He was employed as central station engineer by the Westinghouse company at East Pittsburgh, Pa., from 1929 to 1939. In 1939 he was appointed director of the school of electrical engineering, Cornell University. He is the author of various technical articles and has received honorable mention in the Institute's national best paper prize awards. His AIEE committee memberships include: protective devices, 1933–43; power transmission and distribution, 1939–43; standards, 1941–42; technical program 1941–42, education, 1939–40, 1941–42; basic sciences, 1940–43 (chairman 1941–42). He is a member of Tau Beta Pi and Sigma Xi.

H. H. Race (A '24, F '39) research engineer, General Electric Company, Schenectady, N. Y., has been appointed 1943–44 chairman of the AIEE publication com-

R. W. Ager

M. J. McHenry

C. C. Levy

H. H. Race

mittee. Dr. Race has served on this committee since 1938. Born February 12, 1899, at Buffalo, N. Y., he was graduated from Cornell University in 1922 with the degree of electrical engineer and in 1927 received the degree of doctor of philosophy. From 1920 to 1922 he was instructor in the electrical-engineering laboratory at Cornell University, Ithaca, N. Y. In 1922 he became distribution engineer for the Philadelphia (Pa.) Electric Company. During 1922 and 1923 he was also instructor in the evening session of Drexel Institute, Philadelphia, Pa. He returned to the position of instructor at Cornell University in 1923 and in 1927 he became assistant professor. He joined the General Electric Company as research engineer in 1929. As such he has been responsible for work on the electrical properties of liquid and solid insulating materials. He has held the offices of chairman, 1935–36, and secretary, 1932–34, in the Schenectady Section. His committee activities include: research, 1930–41; basic sciences, 1933–43 (chairman, 1942–43); Sections 1936–40, 1943 (chairman, 1938–40); planning and co-ordination, 1938–40; standards, 1942–43; and technical program, 1942–43. Author of numerous technical articles, he is also a member of the American Association for the Advancement of Science, the American Physical Society, and the National Research Council.

M. J. McHenry (A '11, M '20) director of sales promotion, Hydro-Electric Power Commission, Toronto, Ont., has been appointed 1943–44 chairman of the AIEE committee on transfers of which he has been a member since 1941. Born in Catasauqua, Pa., August 8, 1888, he was graduated from McGill University with the degree of bachelor of science in 1910. From 1910 to 1912 he was engaged in the design of hydroelectric power stations with Smith, Kerry, and Chase, Consulting Engineers, Toronto. He joined the Canadian General Electric Company, Toronto, as sales engineer in 1912 and became assistant manager of the Toronto district office in 1916. From 1918 to 1924 he was manager and secretary-treasurer of the Walkerville (Ont.) Hydro-Electric System. He was made manager of the Ferranti Electric Company, Ltd., Toronto, in 1924 and manager of the United States sales department of the Canadian General Electric Company in 1926. In 1930 he was appointed district manager for Ontario, and in 1938 director of sales promotion for the Hydro-Electric Power Commission. For 1937–39 he served as vice-president of the Institute and has been a member of the committee on general power applications, 1920–22, 1937–38; and the committee on industrial power applications, 1938–43. He is a member of the Association of Professional Engineers of Ontario, the Electric Club of Toronto and the Electric Service League of Toronto.

R. W. Ager (A '24, M '41) associate professor, school of electrical engineering, Cornell University, Ithaca, N. Y., has been appointed chairman of the 1943–44 committee on basic sciences of which he has been a member since 1941. Born January 30, 1898, in St. Peter, Minn., he received from the California Institute of Technology the degrees of bachelor of science in electrical engineering in 1922 and doctor of philosophy, *magna cum laude*, in 1933. From 1923 to 1931 he was inspector and research assistant with the Southern California Edison Company, Ltd., Los Angeles. In 1934 he became assistant professor of electrical engineering at the University of California, Berkeley. He was appointed associate professor of electrical engineering in charge of the high-voltage laboratory at Cornell University in 1941. He has published several technical papers and is a member of the Society for the Promotion of Engineering Education, Tau Beta Pi, Sigma Xi, and Eta Kappa Nu.

C. C. Levy (A '33) industrial engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., has been appointed chairman of the AIEE committee on electrochemistry and electrometallurgy for 1943–44. Mr. Levy has served on the committee since 1934 and held the chairmanship for 1940–41 as well. Born September 18, 1886, in Lucea, Jamaica, B. W. I., he attended Toronto University. He commenced his career as a switchboard operator for the New York (N. Y.) Edison Company, in 1905 and 1906. During 1912–13 he worked as electrical draftsman with the Canadian General Electric Company, Toronto, Ont. He joined the Westinghouse Electric and Manufacturing Company, in 1913 as switchboard draftsman and from 1916 to 1920 he was designing engineer with the switchboard department. In 1920 he was placed in charge of switchboard drafting and in 1922 became automatic switching engineer. Since 1930 he has been engaged in application engineering specializing in electrochemical and chemical industries.

J. C. Damon (A '05, M '13) colonel, United States Army, on the staff of the price-adjustment section, War Department, Washington, D. C., has been retired from the Army. A graduate of Massachusetts Institute of Technology, Colonel Damon started his career in the utility field as design and construction engineer from 1905 to 1913 with the Chicago (Ill.) Telephone Company, the Telluride Company of Colorado, the Trinidad Electric Transmission Railway and Gas Company, and the Electric Bond and Share Company, New York, N. Y. He was assistant chief engineer for the Utah Power and Light Company, Salt Lake City, from 1913 to 1917. During World War I he rose from the rank of captain to that of major in the United States Army. Most of his service was in the power section of the War Industries Board. From 1919 to 1922 he worked on development plans for the West Penn Power Company. In 1922 he joined Stone and Webster, Boston, Mass., and in 1924 the American Brass Company. From 1927 to 1933 he was an executive in the construction division of Jackson and Moreland, Boston. He was made chief engineer of the Public Service Commission of Wisconsin in 1933. Appointed to the Securities and Exchange Commission, Washington, in 1935, he was supervising engineer of its Public Utilities Division until 1941. In 1941 he returned to active duty as major and chief of the Advance Planning Unit Construction Division, Office of the Quartermaster General. Later he was made chief of the power branch of the Army–Navy Munitions Board. Promoted to lieutenant colonel and finally colonel in 1942, he was transferred to the conservation branch of the Production division of the Army Service Forces. In 1943 he was attached to the price-adjustment section.

D. T. May (M '28) mechanical-apparatus engineer, Bell Telephone Laboratories, Inc., New York, N. Y., has retired. After receiving his bachelor of science degree in mechanical engineering from the University of Illinois in 1905, Mr. May joined the Western Electric Company, Chicago, Ill., as a student engineer. In 1909 he was transferred to the company's physical laboratory in New York. During 1910 and 1911 he was a group head at the laboratory. From 1911 to 1917 he was engaged in designing and testing electrical protective apparatus and systems and studying inductive interference. He continued in this field in a supervisory position after 1917. Moving to Bell Laboratories in 1925, he became department head in the general development laboratory in charge of mechanical and electrical analysis of apparatus. In 1933 he added the supervision of materials investigations to his duties and in 1935 was named mechanical-apparatus engineer. A number of patents have been issued in his name and he has represented Bell Laboratories at various times on committees of the Edison Electric Institute, the American Society for Testing Materials, the American Standards Association, and the Association of American Railways.

J. H. Davis (A '03) chief engineer of electric traction, Baltimore and Ohio Railroad Company, Baltimore, Md., has retired. Since he received the degree of electrical engineer from the University of Arkansas in 1901, Mr. Davis has been connected with the railroad industry. His first position was assistant engineer with the Choctaw, Oklahoma, and Gulf Railroad in 1901. Joining the Pennsylvania Railroad, Altoona, Pa., in 1901 as draftsman and engineer, he became assistant electrical engineer in 1905, and electrical engineer in 1908. He had been chief engineer of electric traction for the Baltimore railroad since 1925. As such he designed the first air-conditioned railway passenger car in 1929, and also adapted air conditioning to storage bins. In 1932 he was granted authority by the Baltimore Railroad to install a research plant for the further development of his radio-wave method of exterminating insects in grain and increasing its germination, growth, and yield properties.

W. F. Sims (A '20, F '33) chief electrical engineer, Commonwealth Edison Company, Chicago, Ill., has retired. He commenced his engineering career as assistant engineer with the Chicago (Ill.) Telephone Company from 1897 to 1901. As construction engineer, he worked for the Chicago Edison Company from 1901 to 1906. In 1907 he became field engineer of the Board of Supervising Engineers of Chicago Traction and in 1911 joined Stone and Webster Engineering Corporation, Boston, Mass., as construction engineer. He was associated with William McMunn, consulting engineer, Chicago, during 1915 and 1916. He was made field engineer for the Commonwealth Edison Company in 1916, and inside plant engineer in 1930. In 1932 he was appointed chief electrical engineer.

R. H. Manahan (M '22) chief of the electrical division, building and safety department, City of Los Angeles, Calif., has retired. Mr. Manahan, an 1895 graduate of Stanford University, started his career in the office of the chief engineer of the Los Angeles Railway Company from 1895 to 1897. He worked on underground construction and switchboard construction for the Southern California Edison Company Ltd., Los Angeles, from 1897 to 1899. In the latter year he entered the employ of the City of Los Angeles as electrical inspector. In 1901 he was made head of the city's electricity department which was later incorporated into the building and safety department.

Millard Westrate (A '37) formerly electrical engineer, Commonwealth and Southern Corporation, Jackson, Mich., has been appointed chief engineer, Communication Equipment and Engineering Company, Chicago, Ill. Receiving the degree of bachelor of science from the University of Michigan in 1930, Mr. Westrate was employed in the frequency change department of the Consumers Power Company, Jackson. In 1935 he became power sales engineer. Since 1936 he has been engaged in special studies in the electrical-engineering department of the Commonwealth and Southern Corporation.

G. M. Armbrust (A '11, F '33) formerly assistant chief electrical engineer, Commonwealth Edison Company, Chicago, Ill., has been appointed chief engineer of that company. Mr. Armbrust has been connected with the Edison company since 1902 when he was employed as a draftsman. He became chief draftsman in 1912, staff engineer in 1919, and system development engineer in 1932. Later in 1932 he was appointed assistant chief electrical engineer. He is a member of the Western Society of Engineers. **W. G. Kelley** (A '08, F '26) plant design engineer since 1932, will succeed Mr. Armbrust as assistant chief electrical engineer. Mr. Kelley joined the Edison company in 1901.

W. J. Russell (M '37) formerly manager of engineering, electric-appliance division, Westinghouse Electric and Manufacturing Company, Mansfield, Ohio, has been appointed vice-president in charge of engineering for Landers, Frary and Clark, New Britain, Conn. Coming to the United States from Scotland in 1920, Mr. Russell joined the Westinghouse Electric and Manufacturing Company, East Springfield, Mass., in 1923 as tool and die maker. In 1926 he became time-study engineer and in 1928 manufacturing engineer. He was transferred to Mansfield as supervisor of manufacturing operations in 1931. In 1933 he was appointed manager of engineering.

D. J. O'Conor, Jr. (A '38) president, Formica Insulation Company, Cincinnati, Ohio, has been appointed one of the five members of the plastics industry to serve on a national industry Advisory Committee for Plastic Thermosetting Laminates.

S. G. Hibben (A '34) director of applied lighting, Westinghouse Lamp Division, Bloomfield, N. J., has been elected treasurer of the Illuminating Engineering Society.

N. M. Levinson (A '42) junior engineer, Rural Electrification Administration, St. Louis, Mo., and ensign, United States Naval Reserve, has been called to active duty.

C. W. Leihy (A '30, M '38) formerly engineering editor of *Electrical West* and *Electric Light and Power* is now a lieutenant colonel in the United States Army.

P. S. Millar (A '03, M '13) president of the Electrical Testing Laboratories, New York, N. Y., has been elected president of the New York Electrical Society.

V. K. Zworykin (M '22) associate director, RCA Research Laboratories, Camden, N. J., recently was elected a member of the National Academy of Sciences.

OBITUARY • • • •

Gustavus Adolphus Anderegg (A '04, F '30) retired cable-development engineer, Bell Telephone Laboratories, Inc., New York, N. Y., died August 14, 1943. Born March 30, 1873, at Ragersville, Ohio, he received the degree of bachelor of science from Oberlin College in 1899. In 1900 he received the degree of bachelor of arts and in 1902 the degree of master of arts from Harvard University. From 1902 to 1904 he worked in the development laboratory of the Western Electric Company, first in Chicago, Ill., and later in New York, N. Y. During 1904–05 he was temporary instructor of electrical engineering at Harvard University, Cambridge, Mass. From 1905 to 1908 he served as associate professor of electrical engineering at Ohio State University, Columbus. He returned to the Western Electric Company in 1908 and a year later was transferred to Chicago where he was directly responsible for investigations leading to the manufacture of the first lead-covered toll telephone cable employing loaded phantom circuits. In 1913 he was placed in charge of all lead-covered cable developments in the engineering department of the Western Electric Company and after 1925 at Bell Laboratories. Returning to New York in 1918 he added the duties of transmission branch engineer and head of the physical laboratory to his cable-development work for a time. In the years following he spent much time in England and Germany in connection with the development of submarine cables. The first high-speed permalloy-loaded telegraph cable which revolutionized ocean cable telegraphy was developed through his efforts. This cable was laid between New York and the Azores in 1924. Other important cables manufactured and laid under his supervision include one from Key West, Fla., to Havana, Cuba, in 1922; one from Fanning Island to Suva in the Fiji Islands and one from the Azores to Emden, Germany, in 1926. He was joint holder of several patents and a member of the American Association for the Advancement of Science, the Montclair Society of Engineers, the Harvard Engineering Society, and the Telephone Pioneers of America.

John Emile Boesch (A '08, M '13) owner, Oficina Tecnica "Rotor," San Salvador, Salvador, died July 7, 1943. Born May 21, 1878, in Winterthur, Switzerland, he was graduated from the Technical College of Winterthur as an electrical and mechanical engineer in 1899. As draftsman and designer he was employed by Brown Boveri and Company, Switzerland during 1899 and 1900. In the same capacity he worked for the French Westinghouse Company, Havre, from 1900 to 1902, and for the British company at Manchester, England, from 1902 to 1905. During 1905 and 1906 he served as designer for C. O. Mailloux, consulting engineer, New York, N. Y. While in this position one of his projects was the steam-plant layout of the Engineering Societies' Building in New York. After the earthquake of 1906 he redesigned several substations and generating stations for the Underground Railroad, San Francisco, Calif. He worked as designer and chief inspector for the Mexican Light and Power Company, Mexico City, from 1907 to 1910. In 1910 he became distributing engineer for the British Columbia Electric Railway, Ltd., Vancouver. In 1917 he went to Peru as electrical and mechanical engineer for the Cerro de Pasco Mining Company, Lima. From 1918 to 1927 he was technical engineer for the Cia. Alumbrado, Iniquique, Chile. Joining the Oficina Tecnica, San Salvador, Salvador, in 1927 as engineer, he became its owner in 1934.

William E. Rook (A '43) engineer, American Telephone and Telegraph Company, Chicago, Ill., died July 24, 1943. He was born at Chicago, September 11, 1904. In 1923 he was employed as communications engineering draftsman at the Hawthorne plant of the Western Electric Company, Cicero, Ill. Joining the American Telephone and Telegraph Company in 1925, he was engaged chiefly in outside plant installations. For two periods, from 1932 to 1936 and again from 1938 to 1940, he devoted his time to study of transmission-line difficulties and their correction. Since 1942 he had been engineer in charge of the drafting room.

MEMBERSHIP • •

Recommended for Transfer

The board of examiners, at its meeting on September 23, 1943, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

Butcher, C. A., Mgr., Pacific Coast Dist. Mfg. & Repair Dept., Westinghouse Elec. & Mfg. Co., Emeryville, Calif.
Hollister, F. H., chief electrical engr., Sargent & Lundy, Chicago, Ill.
Hunt, J. H., director, New Devices Section, General Motors Corp., Detroit, Mich.
Hynes, L. P., electrical and mechanical engr., Camden, N. J.
Lacy, T. N., vice-pres. and general mgr., Michigan Bell Telephone Co., Detroit, Mich.

To Grade of Member

Bany, Herman, application engr., General Electric Co., Philadelphia, Pa.
Barry, R. L., electrical engr., Research Dept., Goodman Mfg. Co., Chicago, Ill.
Bean, G. W., chief engr., Texas Electric Service Co., Fort Worth, Tex.

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Names of applicants in the United States and Canada are arranged by geographical District. Any member objecting to the election of any of these candidates should so inform the national secretary before October 31, 1943, or December 31, 1943, if the applicant resides outside of the United States or Canada.

To Grade of Fellow

Burt, R. C., Lockheed Aircraft Corp., Burbank, Calif.

To Grade of Member

Ayers, J. W., C. P. Clare & Co., Chicago, Ill.
Caminiti, P. A., Brewster Aero. Corp., Long Island City, N. Y.
Clarke, C. G. C. (Re-election), The English Elec. Co., Ltd., Stafford, England.
Dudley, B. (Re-election), McGraw-Hill Pub. Co., New York, N. Y.
Duttera, W. S., Natl. Broadcasting Co., New York, N. Y.
Hurd, B. B. (Re-election), Hatfield Elec. Co., Oil City, Pa.
Ikola, E. (Re-election), Koppers Co., Pittsburgh, Pa.
Johnston, B. H., Moloney Elec. Co. of Canada, Ltd., Montreal, Que., Can.
McGuire, D. B. (Re-election), Rockland Light & Power Co., Middletown, N. Y.
Mosman, C. R. (Re-election), Amer. Tel. & Tel. Co., Chicago, Ill.
Muth, A. J. (Re-election), Albert Kahn Associated, Detroit, Mich.
Puri, A. N., Military English Services, Punjab, India.
Read, W. V. (Re-election), Curtiss-Wright Corp., Caldwell, N. J.
Rimmer, G. M., City Gas Works, Birmingham, England.
Shoard, W. H., Geo. A. Fuller Co., Chicago, Ill.
Thacker, R. S., Cannon Elect. Dev. Co., Los Angeles, Calif.
Tuttle, A. N., Walworth Co., Inc., East St. Louis, Ill.
VanHoose, J. E., Rural Elec. Admin., St. Louis, Mo.
Wilson, C. C., Ward Leonard Elec. Co., Mt. Vernon, N. Y.

19 to grade of Member

To Grade of Associate

United States and Canada

1. North Eastern

Albach, C. R. (Re-election), U. S. Engineer Office, Buffalo, N. Y.
Brown, H. A., Rochester Gas & Elec. Corp., Rochester, N. Y.
Maginniss, F. J., Gen. Elec. Co., Schenectady, N. Y.

2. Middle Eastern

Augsburger, H. M., Kimble Glass Co., Vineland, N. J.
Braun, H. J., Westinghouse Elec. & Mfg. Co., Lima, Ohio.
Byrd, H. L., Gen. Elec. Co., Philadelphia, Pa.
Derrick, W. A., Philco Corp., Sandusky, O.
Foltz, H. M., Jr., Lowry Elec. Co., Inc., Williamsport, Pa.
Grim, C. D. (Re-election), Gilbert Associates, Inc., Reading, Pa.
Lippitt, H. F., 2nd Lieut., USNR, Washington, D. C.
Orellana, I. G., Republic Steel Corp., Cleveland, Ohio
Woods, W. O., Gen. Elec. Co., Erie, Pa.
Wynkoop, W., Bethlehem Steel Co., Bethlehem, Pa.

3. New York City

Bachand, G. R., Westinghouse Elec. & Mfg. Co., Bloomfield, N. J.
Brodsky, L., Jr., Federal Tel. & Radio Corp., Newark, N. J.
Bulzing, W., Burns & Roe, Inc., New York, N. Y.
DeCew, A. E., Ward Elec. Co., Mt. Vernon, N. Y.
Emigh, C. R., Westinghouse Elec. Elev. Co., Jersey City, N. J.
Fitchen, J. H. (Re-election), Burns & Roe, Inc., New York, N. Y.
Florez, H., Cons. Radio Engr., 41–29 41st St., Long Island City, N. Y.
Hickstein, Beatrice A., Western Elec. Co., Kearny, N. J.
MacCoun, T. D., Link Radio Corp., New York, N. Y.
Scheib, J., Jr., Ward Leonard Co., New York, N. Y.
Schram, R. E., Aluminum Co. of America, Maspeth, L. I., N. Y.
Solbrig, A. L., 1st Lt., U. S. Army, Allenhurst, N. J.
Squire, E. M. (Re-election), Mfrs. Tech. Rep., New York, N. Y.
Tiernan, T. F. (Re-election), American Dist. Tel. Co., New York, N. Y.
Wappler, A. C., Wappler, Inc., New York, N. Y.

4. Southern

Erlandson, N. H., Carolina Power & Light Co., Raleigh, N. C.
Liverman, R. B., Newport News Shipbuilding & Dry Dock Co., Newport News, Va.
McCracken, H. R., T.V.A., Chattanooga, Tenn.
Purdum, W. F., Waterman Steamship Corp., Mobile, Ala.
Simpson, J. G., Westinghouse Elec. & Mfg. Co., Chattanooga, Tenn.

5. Great Lakes

Angelakos, D. J., University of Notre Dame, Notre Dame, Ind.
Boldt, R. E., U. S. Navy Dept., Milwaukee, Wis.
Glyptis, N., Bell & Howell Co., Chicago, Ill.
Hastings, H. R., A.C. Spark Plug Div., G.M. Corp., Flint, Mich.
Kalina, G. F., Gen. Motors Corp., Detroit, Mich.
Lehrkind, A., Allis-Chalmers Mfg. Co., West Allis, Wis.
Linfor, J. P., Penn Elec. Switch Co., Goshen, Ind.
Mauver, G. N., U. S. Navy Dept., Milwaukee, Wis.
Nader, J., Eicor, Inc., Chicago, Ill.
Quigley, A. J., University of Nore Dame, Notre Dame, Ind.
Saunders, H. O. (Re-election), Illinois Bell Tel. Co., Chicago, Ill.
Scalone, J. M., Allis-Chalmers Mfg. Co., West Allis, Wis.
Scofield, D. W., Electromaster, Inc., Detroit, Mich.
Stringer, W. A., Gen. Motors Corp., Detroit, Mich.
Wadel, A. G., Studebaker Aviation, South Bend, Ind.
Zamsky, J., Square D. Co., Milwaukee, Wis.

7. South West

Boughan, J., J. Gordon, Turnbull, Sverdrup, & Parcel, St. Louis, Mo.
Garland, C. E., Texas Elec. Serv. Co., Fort Worth, Tex.
Gates, L. B., Rural Elec. Adm., St. Louis, Mo.
Heins, E. F. (Re-election), Southwestern Bell Tel. Co., St. Louis, Mo.
Kesler, J. P., West. E. & M. Co., Kansas City, Mo.
Moszcynski, S., Rural Elec. Adm., St. Louis, Mo.
Neukomm, W. H., Southwestern Bell Tel. Co., Tulsa, Okla.
Shiozawa, S., Rural Elec. Adm., St. Louis, Mo.
Simmons, E. J., Maloney Elec. Transformer Co., St. Louis, Mo.
Strojny, J. S., Rural Elec. Adm., St. Louis, Mo.
Sweet, E. A., Union Electric Co. of Mo., Webster Groves, Mo.
White, C. E., Rural Elec. Adm., St. Louis, Mo.

8. Pacific

Newman, J. E., Signal Office, San Francisco, Calif.

9. North West

Baker, A. M., Lieut. (j.g.), USNR, Tacoma, Wash.
McCoombs, R. E., Great Northern Ry., Wenatchee, Wash.
Riechel, D. A., Pacific Tel. & Tel. Co., Portland, Oreg.

10. Canada

Gillett, G. H., Canadian Gen. Elec. Co., Ltd., Montreal, Que., Can.

Elsewhere

Das, S. C., Indian Institute of Science, Bangalore, India.
Mare, A. J., Dubilier Condenser Co., Birmingham, England.
Vilela, J. O. C., Brazil Govt., Rio de Janeiro, Brazil, S. A.

Total to grade of Associate
United States and Canada, 66
Elsewhere, 3

OF CURRENT INTEREST

U. S. Army Requests Radio and Photographic Equipment

Although hundreds of short-wave sets and other amateur radio apparatus, and scores of fine cameras which once belonged to private citizens, now are used by Signal Corps units of the Army Service Forces, even greater quantities of this type of equipment are needed.

Purchases of radio equipment from individuals are confined to certain high-grade or scarce instruments which no longer are manufactured or which are needed in greater quantities. The list of "wanted" instruments ranges from standard and commercial short-wave sets to ordinary meters. The greatest need, however, is for testing equipment: oscilloscopes, signal generators, and tube checkers.

In the photographic field, good lenses, especially larger telephoto lenses, and sound cameras are needed most. High-grade movie cameras, both 35- and 16-millimeter, professional press and miniature still cameras, exposure meters, range finders, pack adapters, and cut film holders also are on the photographic list.

All material is shipped to troops overseas or to Army training schools, or allocated to the Federal Bureau of Investigation. Owners who wish to sell radio or photographic equipment to the Army Signal Corps should write to the Emergency Purchase Section, Philadelphia Signal Corps Procurement District, 5000 Wissahickon Avenue, Philadelphia, Pa. Letters to that office listing the equipment for sale are promised prompt attention.

Civil Service Commission to Fill Many Openings for Draftsmen

Over a hundred draftsmen are being sought by the United States Civil Service Commission for Federal agencies whose work is necessary to the prosecution of the war. Particularly wanted are ship, electrical, and mechanical draftsmen, as well as topographic draftsmen. In addition, the Treasury Department and the War Production Board can utilize statistical draftsmen.

Qualified engineering draftsmen in any field are urged to apply. Agencies with the most pressing needs are the Navy Department, the Coast and Geodetic Survey of the Department of Commerce, and the Geological Survey of the Department of the Interior. Most of the positions are in Washington, D. C., but some vacancies exist throughout the United States and its possessions.

Salaries range as high as $3,163 a year including pay for 8 hours overtime incorporated in the 48-hour Federal work week. For the higher-paying positions in all fields, experience or study in drafting appropriate to the grade of the position is necessary. Persons now employed at their highest skills should not apply as Federal appointments are made in accordance with War Manpower Commission policies and employment stabilization plans.

Those interested may secure Announcement 283 and application forms from first- and second-class post offices; from Civil service regional offices; or from the United States Civil Service Commission. Applications should be forwarded to the United States Civil Service Commission, Washington 25, D. C.

Variety of Power Units Employed by Signal Corps

As many as 60 different types of gasoline- or Diesel-engine power units are employed by the Signal Corps, United States Army Service Forces, for ground use alone. They range all the way from the 45-pound 300-watt portable type which a soldier can easily carry in his pack and which supplies energy for a special telephone system, to a 50,000-watt special-purpose power unit. Some have particular uses, and some are designed for a multiplicity of purposes. All have two things in common: they are built to stand up under any climatic handicaps, and are designed not to create radio interference.

As the Signal-Corps power units may follow the United States troops into all parts of the world, they are tested to operate at temperatures ranging from 40 degrees below zero to 130 degrees above zero, Fahrenheit. Auxiliary starting aids, which apply heat to the crankcase, intake manifold carburetor, and battery, are used for starting the power units in cold climates. Self-starters are used on most of the larger units, some of which may be operated by remote control, while rope starters are provided for the smaller equipment. Similarly, water-cooling is provided on the majority of larger equipment, air-cooling on the smaller ones.

Canada Expands Power Supply to Increase War Production

Canada's great resources of electric power provide one of the basic reasons why the Dominion now holds fourth place among the United Nations as a war producer, Honorable C. D. Howe, minister of munitions and supply, said recently in a report to the House of Commons on Canada's manufacturing progress.

Since 1938, when Canada's power installations, developed over a period of 45 years, totaled 7,155,000 horsepower, new wartime developments, including the enormous Shipshaw undertaking and certain other projects not yet completed, will have added an effective electrical capacity of 1,870,000 horsepower.

Since the beginning of the war, interconnections between power systems have been made more elastic and of greater capacity. Power has been loaned from time to time between the United States and Canada, transmitted to the United States at Niagara and taken from the United States at Beauharnois, or vice versa, depending on the needs of the moment.

In Ontario, production has been increased materially by the completion of the Big Eddy and Madawaska developments, and installation of the submerged weir in the Niagara River. The De Cew Falls development is nearing completion. In Quebec, the Shipshaw development, alone, has increased installations this year by 600,000 horsepower, and all the power companies have added to their output. In Alberta, the Minnewanka project has been completed, and in British Columbia, the Brilliant development is proceeding.

In all the provinces improved storage facilities, together with the installation of new machinery, have made more power available. The gas situation also has been improved by additional drilling in southwestern Ontario and by completion of a part of the new coke-oven gas plant at Hamilton, Ont.

Resources of Occupied Europe Absorbed by Nazi Industrialists

Nazi big business is rapidly swelling the profits of plunder through the absorption of the electric-power resources and light-metal industries in occupied countries, especially Norway and the Balkans, according to the latest report from the Office of War Information survey of the economic invasion of Europe which has followed in the wake of military conquest. In addition to this appropriation, a single German company, Kontinentale Oel A.G., controlled by a business alliance of Nazi party leaders and important German bankers and industrialists, holds a virtual monopoly over the entire oil business in the conquered countries of Europe.

A key firm in the Norwegian aluminum industry, A.S. Norsk Lettmettall, in Oslo, is almost completely dominated by German interests, three firms each owning one third of its capital. Of these firms, two are German: I.G. Farbenindustrie, the great German dye trust, and the Nordische Aluminum A.G., in Berlin, controlled by the German Air Ministry. The third firm, Norsk Hydro A.G., is held partly by Germans, partly by Norwegians. I.G. Farbenindustrie now operates the great industrial center of Rjukan, which includes Norway's largest electric-power station as well as important chemical industry plants.

In the Balkans the Nazis have concentrated on developing full electrification with consequent profits to German firms. The German company, Energieversorgung Suedsteiermark, which absorbed the electrical enterprises in northwestern Yugoslavia, is now building a 100-kv cable between Reichenberg and Zagreb. In eastern Europe, the Nazis have set up a number of new companies which share profits of electrical development with the older German concerns. At the same time these older concerns are also erecting plants for production and distribution of electric power, and for the sale of electrical products.

Kontinentale Oel, capitalized at 80,000,000 marks ($32,000,000), operates only outside Germany, chiefly in southeastern Europe. Within a few months after it began operations, it had control of over 15 per cent of all Rumanian oil capital. Today there is probably not a single oil company in Rumania that is not subject to the German combine.

The Hungarian oil industry is controlled through one of the major stockholders in Kontinentale Oel, Wintershall A.G. Kontinentale's monopoly over the oil interests of Poland is controlled through a new subsidiary, Karpathan Oil, A.G.

Data in this report were assembled by OWI analysts from reports of Government agencies, and from materials appearing in the European press and radio.

Conrad N. Lauer, Founder of Hoover Medal, Dies

Conrad Newton Lauer, who donated the trust fund for the periodical award of the Hoover Medal "to a fellow engineer for distinguished public service," died August 2, 1943.

The Medal, which was awarded first to Herbert Hoover (HM '29) in 1930, has been presented four times to AIEE members. The second award of the Medal was made to Ambrose Swasey (HM '28) in 1936, the fourth to Gano Dunn (F '12) in 1939, and the sixth award to Gerard Swope (F '22) in 1942. Medalists are selected by a board of award representing the national societies of civil, mining, and metallurgical, mechanical, and electrical engineers.

Doctor Lauer was born November 25, 1869, in Three Tuns, Montgomery County, Pa., and was educated at public and private schools in his native county. He was awarded the honorary degrees of mechanical engineer, by Stevens Institute of Technology in 1930, and doctor of laws, by the University of Pennsylvania in 1940.

He was employed first by the Link-Belt Company from 1893 to 1902 in various positions from time clerk to acting superintendent. In 1902 he joined the firm of Dodge and Day, Philadelphia, Pa., as industrial engineer. When this firm was incorporated as Day and Zimmermann in 1916, he was made treasurer, general manager, and director. Later he became vice-president of the firm, and remained with it and its successors until 1929. In the latter year he was appointed president and director of the Philadelphia Gas Works. He resigned the presidency about a year ago and became chairman of the board.

He served as director of several steel companies, Cyrus Fogg lecturer at Princeton University, and special lecturer at the University of Pennsylvania at various times.

A past-president of the American Society of Mechanical Engineers, he was also a member of the American Gas Association, the Pennsylvania Chamber of Commerce, the American Academy of Political and Social Science, the Newcomen Society, the Franklin Institute, the Pennsylvania Society of Fine Arts Society, the Civic Safety Fund of Philadelphia, the boards of award for the Hoover and John Fritz Medals, and the Industrial Research and Development Bureau.

NRC Chemistry Committee Issues Review of Insulation

A 72-page pamphlet, "Contributions of the Chemist to Insulation Research for January 1942–January 1943," has been issued by the committee on chemistry of the National Research Council's Conference on Electrical Insulation.

Each of the six articles in the annual review, which is prepared to stimulate interest in insulation problems as well as to aid the insulation engineer, contains an extensive bibliography. In the current issue the field of anomalous electrical dispersion, and progress in rubber insulation are reviewed. Also treated are insulating paper, synthetic-plastic electrical insulation, and chemical progress on insulating oils. A section on ceramic and glass insulation has been added for the first time.

Copies may be obtained without charge, as long as the supply lasts, from G. T. Kohman, chairman of the committee on chemistry, Bell Telephone Laboratories, Murray Hill, N. J.

Merchant Marine Needs More Men

With each new invasion and newly delivered ship calling for additional skilled merchant seamen, the demands on that service grow heavier. On it rests the responsibility for delivering the gasoline, food, tanks, planes, guns which will insure the United Nations superiority on the fighting fronts.

Men who have been issued certificates for service in the United States merchant marine at any time in the past are urged by Marshall Dimock, assistant deputy administrator for recruitment and manning of the War Shipping Administration, to consider returning to the merchant marine service. In recent months, reports Mr. Dimock, more than 20,000 men of various professions and trades have returned to merchant marine posts, which helped the war effort more directly than their civilian jobs.

From a potential working force of 500,000 men who have been issued certificates for service since 1937, the merchant marine is endeavoring to recruit the mates, engineers, and able-bodied seamen, so badly needed at present. Mr. Dimock pointed out that 42 skilled men are needed to operate each of the five ships now completed daily.

Applicants for merchant marine berths may write the Recruitment and Manning Organization, Washington, D. C., or apply at the nearest United States Employment Service office.

NEMA Revises Brush Standards. A new edition of, "Carbon, Graphite and Metal-Graphite Brush Standards" (Publication 43-85), which supersedes the 1934 edition, has been published by the National Electrical Manufacturers Association. Standard dimensions and tolerances for carbon, graphite, and metal-graphite brushes, as well as standards for associated parts of brushes—cables, clips, and connections—are covered by the text. Uniformity of terminology is given attention in a special section devoted to definitions. Copies of the 16-page illustrated pamphlet may be obtained from NEMA, 155 East 44th Street, New York, N. Y., at 25 cents per copy.

Brazil's Power Supply Expanded for New Aluminum Industry

The first generators and transformers for power stations which will generate 6,000 kw of power for Brazil's new aluminum industry are now being installed, according to officials of the International General Electric Company.

When in 1940 the 1,600-odd tons of aluminum which Brazil imported annually from the United States were cut off by the enormous demands of the domestic aircraft industry, the Brazilian government laid plans to speed development of its 81 known deposits of bauxite estimated to contain approximately 150,000,000 tons. Electro Quimica Brasilera, a local power utility, made plans to enlarge its power facilities at three points—Saramenha, Cabolco, and Funil—in order to serve a projected aluminum plant near Ouro Preto, an important center in the state of Minas Geraes, which alone contains an estimated 120,000,000 tons.

Heretofore, Brazilian aluminum output, confined to the yield of surface mines, has been used mainly in the production of insecticides and of sulphate of aluminum for purifying Brazilian and Argentine water supplies. Eventually the Brazilian government expects to organize an aircraft industry for producing cargo planes that will be used in getting supplies to and from the interior.

Future Meetings of Other Societies

American Institute of Chemical Engineers. 36th annual meeting, November 15–16, 1943, Pittsburgh, Pa.

American Institute of Mining and Metallurgical Engineers. Petroleum division, October 21–22, 1943, Los Angeles, Calif. Industrial minerals division, October 21–23, 1943, Wilmington, Del. Joint fuels conference, October 28–29, 1943, Pittsburgh, Pa. Annual meeting, February 20–24, 1944, New York, N. Y.

American Society of Heating and Ventilating Engineers. 50th annual meeting, January 31–February 2, 1944, New York, N. Y.

American Society for Metals. Annual convention, October 18–22, 1943, Chicago, Ill.

American Society of Mechanical Engineers. Annual meeting, November 29–December 3, 1943, New York, N. Y.

American Welding Society. 24th annual meeting, week of October 18, 1943, Chicago, Ill.

Electrochemical Society. Biannual convention, October 13–16, 1943, New York, N. Y.

Engineers Council for Professional Development. Annual meeting, October 23, 1943, New York, N. Y.

Exposition of Chemical Industries. December 6, 1943, New York, N. Y.

Illuminating Engineering Society. Special one-day meeting, October 13, 1943, New York, N. Y.

National Electrical Manufacturers Association. October 25–29, 1943, New York, N. Y.

National Metal Congress and War Display. October 18–22, 1943, Chicago, Ill.

National Safety Congress and Exposition, October 5–7, 1943, Chicago, Ill.

Society of Automotive Engineers. Fuels and lubricants meeting, November 4–5, 1943, Tulsa, Okla.

Society of Chemical Industry. Presidential dinner, October 22, 1943, New York, N. Y.

Society of Motion Picture Engineers. 54th semiannual technical conference, October 18–22, 1943, Hollywood, Calif.

Society of Naval Architects and Marine Engineers. 50th anniversary and annual meeting, November 10–13, 1943, New York, N. Y.

U. S. Power-Capacity Increase Announced for 1945

Seven specific projects which will add approximately 500,000 kw to the nation's power capacity for 1945 operation were announced recently by J. A. Krug, director of the Office of War Utilities of the War Production Board.

The program, representing the smallest annual increase since the beginning of the war, will consist largely of additions to present plants as follows:

1. Installation of unit 7 at Grand Coulee, adding 108,000 kw rated capacity to this development.

2. Addition of approximately 100,000 kw in existing hydroelectric plants of the Tennessee Valley Authority system, to be completed sometime in 1945.

3. A 20,000-kw steam-power addition to the San Antonio, Tex., municipal plant, to be completed late in 1944.

4. An additional boiler for the Jacksonville, Fla., municipal plant which will increase capacity 15,000 kw. This also will be completed in 1944.

5. An additional unit of 20,000 kw for the Evansville, Ind., steam plant of the Southern Indiana Gas and Electric Company, scheduled for completion in 1944.

6. A 25,000-kw unit for the St. Petersburg, Fla., steam plant of the Florida Power Corporation.

7. A 20,000-kw steam plant at Pensacola, Fla., to be built by the Gulf Power Company. These latter two are scheduled for completion early in 1945.

In addition to these specific projects, 200,000 kw new capacity will be needed for industrial sections of the country dependent on steam power, where 1944 loads are expected to run close to capacity. Sizes of the individual units and the exact locations for them have not been determined as yet.

Southwest Valleys Power Administration Created

The Southwest Valleys Power Administration, created by President Roosevelt to handle the power of three Federal hydroelectric projects in the southwestern section of the United States, became effective September 1, 1943. Douglas Wright, formerly special representative of Federal Works Administrator at the Pensacola project, was named acting administrator of the new agency.

By executive order, Denison Dam, between Oklahoma and Texas, Pensacola Dam, in eastern Oklahoma, and Norfolk Dam, in northern Arkansas, were placed under the Department of the Interior in so far as the distribution and sale of power are concerned. The President also set up an order of priorities for the sale of power, and placed the co-operatives in the second group. Since the Administration was authorized to deliver power over existing facilities, the systems are now virtually common carriers.

New Mathematics Quarterly Issued at Brown University

The second number of a *Quarterly of Applied Mathematics* which is being published under the sponsorship of Brown University, Providence, R. I., has been issued. A board of editors drawn up on a national scale has been appointed, consisting of: H. L. Dryden, National Bureau of Standards, Washington, D. C.; T. C. Fry, Bell Telephone Laboratories, Inc., New York, N. Y.; Theodore von Karman, California Institute of Technology, Pasadena; J. M. Lessells, Massachusetts Institute of Technology, Cambridge; I. S. Sokolnikoff, University of Wisconsin, Madison; J. L. Synge, Ohio State University, Columbus; W. Prager, Brown University, who has been appointed managing editor.

The editors have expressed the hope that the quarterly which was founded, "to meet the needs of certain mathematicians and engineers whose interests extend beyond the accepted boundaries of their respective groups," will cut across the lines of demarcation dividing science into compartments. To fulfil this purpose, papers in applied mathematics of an advanced character are sought. The editors plan to use the common ground of mathematics and engineering as a starting point from which the scope of the quarterly's subject matter will grow.

Mentioned as falling within the legitimate subject matter of acceptable articles are: fluid mechanics, elasticity, plasticity, thermodynamics, classical mechanics, and the particularly fruitful field of electrical engineering. The ideal contribution is defined as one employing advanced and general mathematical methods which lead speedily to results in close agreement with experiment.

The subscription price for the seven by ten inch quarterly is $6.00 per year; single copies $2.00. Subscriptions and orders for single copies may be addressed to: Quarterly of Applied Mathematics, 450 Ahnaip Street, Menasha, Wis., or to Brown University.

New Fire-Protection Policy Adopted by WPB

A new fire-protection policy for safeguarding the nation's most essential resources was adopted recently by the War Production Board. In general, it provides that the materials, components, facilities, and man power required for fire-protective equipment be made available in so far as is compatible with other essential needs and with the objective of securing maximum protection with minimum use of critical materials. Only those resources assigned A ratings by the Resources Protection Board will be provided with fire-extinguishing equipment; other resources will require specific approval by that board.

At the same time the WPB announced the creation of a fire protection committee, headed by Harlow Lewis, chief of the materials control branch of the project division, to which all applications for fire-extinguishing equipment involving construction will be directed. Only applications involving construction, such as sprinkler systems, hydrant and hose systems, and stand-pipe systems will be considered. All other priority applications for fire-extinguishing equipment will be processed by the safety and technical equipment division.

New Photometric Units Adopted in Germany

Before the war interrupted normal international relations, plans had been made to introduce throughout the world on January 1, 1941, a "new" system of photometric units replacing both the international and Hefner systems. An article by Doctor W. Geiss of the Philips Lamp Works, Eindhoven, Holland, in the *Bulletin of the Swiss Association of Electrical Engineers*, volume 33, 1942, pages 395–96, states that the formal change to the new system of units was made in Germany on the date previously set, although the practical transfer still involved some difficulties. Since factors for converting values from the Hefner system to the new one were not published until 1942, some doubt remains as to the extent of use of the new units in actual practice.

The change of units in practical use involves a fundamental difficulty which has delayed the adoption of any one system. This is that the establishment of a basic unit for light of one color is only a partial solution of the problem. There must also be a uniform method of passing from that color to others, which must be chosen arbitrarily, since there is no ground for saying that any one method is correct. The two systems of units hitherto in use have differed not only in the magnitude of the basic unit but also in the relation between lights of different colors.

The principles of the new system which were accepted internationally in 1937, are:

1. To establish a basic unit by taking the brightness of a black-body radiator at the temperature of freezing platinum as 60 candles per square centimeter.

2. To pass from one color of light to others by use of the standard spectral luminosity factors that were originally established by the American Illuminating Engineering Society and have since been accepted internationally.

It was necessary, however, to have practical working standard lamps of various types calibrated according to this new system. In order to make sure that all countries would have concordant standards, lamps of several types were calibrated by the principal national laboratories and compared. This work was to have been finished early in 1939 so that the new units could be put into use January 1, 1940, but it was delayed, because questions were raised regarding the validity of the luminosity factors. These were not settled until the International Commission on Illumination met in June 1939. Plans were then made to complete the comparisons of standard lamps and to introduce the new system in 1941.

The outbreak of the war naturally prevented meetings of the authoritative international bodies dealing with weights and measures. Consequently, no general adjustment of units has been made. The changes in the countries using the present international system will be relatively small, but they will be slightly different in the various countries and for various types of lamps. In the United States likewise, the changes in ratings assigned to types of lamps in practical use will be small, but it has not seemed desirable to introduce the new units until that step can be taken simultaneously in other countries.

Ratios to be used in conversion from Hefner units to the "new" system were published in 1942 by the German Illuminating Engineering Society in *Das Licht*, volume 12, page 35. In 1928 the International Commission on Illumination set up provisionally a similar set of factors as representing the relation between Hefner and international candles for various types of filament lamps. From comparison of these two series of conversion factors, the item cited concludes that the transition from international to new units can be made in Switzerland without any changes in established specifications for lamps or in recommendations regarding illumination.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Nikola Tesla's Achievements in the Electrical Art

To the Editor:

The Tesla article published in *Electrical Engineering*, August 1943, pages 351–357, impels me to send some personal reminiscences which may be of some slight value.

It is a fact not generally known that Tesla offered his patents to The Mather Electrical Company at Manchester, Conn., before going to Westinghouse. When Professor Anthony left Cornell University he went to The Mather Company as chief engineer, and soon after that Tesla came from New York with his motors—several stators and a number of rotors wound in different ways—all two-phase fractional-horsepower. Arrangements had been made for two-phase supply, and the tests covered considerable time.

The Mather Company was controlled largely by the Cheney Silk Industries, and, as they were not disposed to furnish funds necessary to develop the new system, the Tesla offer was rejected, and the honor that might have been Manchester's went to Pittsburgh.

There was a mixture of droll geniality in the Tesla character discernible at times. He told certain hearers that he would place two wires together in powder, and while current was flowing, would separate them without exploding the powder. This seemed a rather remarkable feat, and after some discussion he was asked for a demonstration. He replied that he would use tooth powder. All discussion ceased.

The Mather Company manufactured motors of small capacity, and they were sent out with rather elaborate printed instructions in regard to brush adjustment and general care. Tesla looked over a copy and said: "I will make a motor that may be given to a . . . man with the instructions, 'Here, you . . . fool, grease the bearings.'" This was, indeed, a considerable simplification.

While watching the testing of a motor on the Anthony–Bracket dynamometer then in use he said, "I will make a motor of a thousand horsepower." The largest motor made in Manchester at that time was 40 horsepower, and the sale of a motor of that size was a gala event. His statement seemed like a long look ahead, but it was not many years before a Tesla motor of that capacity was running in Hartford.

FREDERICK G. STRONG (F '13)
(Retired, Wethersfield, Conn.)

Polyphase Armature Windings

To the Editor:

In laying out the connections for a balanced three-phase armature winding with a fractional number of slots per pole per phase, it is sometimes taken for granted that the voltage vectors in the diagram of the winding are separated by equal angles in all cases. It is possible, of course, to take any numerical case and, by finding the angle for each vector, to show that the separations are equal for that case. However, the following general proof may be desirable

Let the number of slots be s and the number of poles be p. Reduce the fraction s/p to r/q by canceling out factors as much as possible; that is, r and q contain no common factor. The letter r then denotes the number of slots in a repeatable section and q the number of poles in a section. For a balanced three-phase winding, r must be divisible by 3.

Since a lower coil side is always at the same phase angle from an upper coil side in the same coil, with the usual diamond coils which are all alike, the voltages developed in all the upper coil sides may be computed first. The voltages developed in the lower coil sides will be the same in magnitude and in relation to each other and may be added on vectorially—in one step—using the usual coil pitch factor.

The position angles in electrical radians, or the phase angles of the fundamental electromotive forces of the upper coil sides of the first few slots of a repeatable section are

$$0, \frac{q\pi}{r}, \frac{2q\pi}{r}, \frac{3q\pi}{r}, \ldots$$

since r slots correspond to q poles, and the angle of the entire section of q poles is $q\pi$. When these angles become greater than π, then π or a multiple of π is to be subtracted, so that the angle is measured on the nearest pole and is always less than π.

An angle $(mq/r-1)\pi$ cannot be the same as any of the preceding angles, since $mq-r-m_1q$ or $(m-m_1)q-r$, cannot equal 0, as q is not a factor of r. Similarly for the nth pole $(mq/r-n)\pi$ cannot be the same as any of the preceding angles, since $mq-nr-(m_1q-n_1r)$, or $(m-m_1)q-(n-n_1)r$, cannot equal 0, because, if it did, r/q would equal $(m-m_1)/(n-n_1)$. But $m-m_1$ is an integer less than r, and $n-n_1$ is an integer less than q. Therefore the fraction r/q would have been reduced to a smaller numerator and denominator, which was stated to be not possible when r and q were defined.

Since every angle is different from all the preceding angles, no two are alike. Therefore there are r different angles all less than π, for the r slots of the section. They are all of the form

$$\left(\frac{mq-nr}{r}\right)\pi$$

all the letters except π being integers. There are r different numerators, all less than r and all integers, including 0, and so they must be

$$0, 1, 2, 3, \ldots (r-1)$$

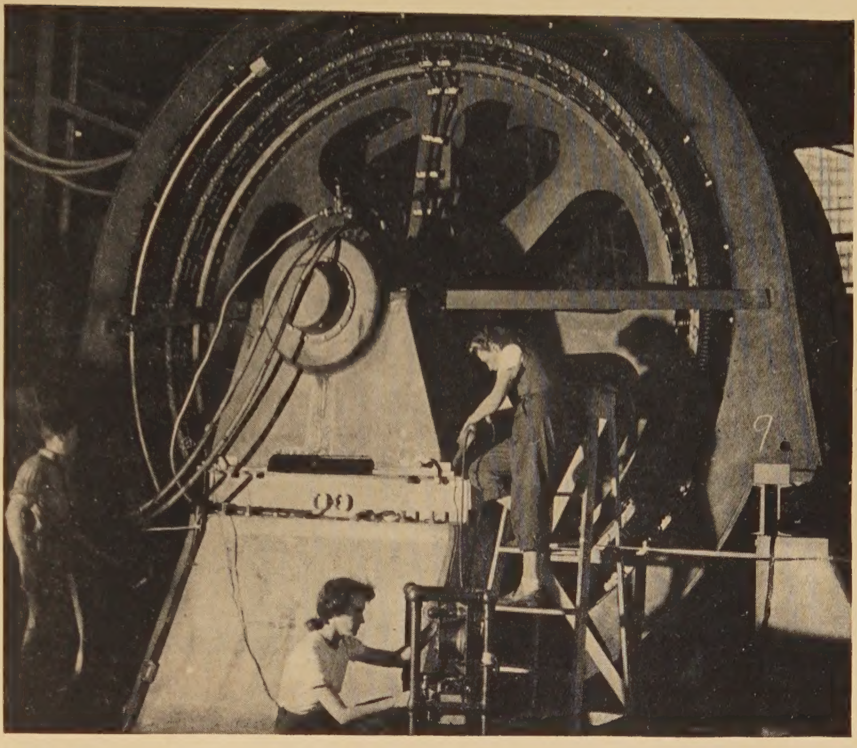
That is, the vector diagram for the fundamental voltage of the slots is a fan with the vectors equally spaced at the angle π/r, when the vectors are drawn from one point.

One third of this fan, covering 60 electrical degrees, may be taken for each of the three phases. This will be the best arrangement, as it will give the largest resultant voltage. Any other arrangement, even though it might give a balanced winding, would involve using one or more vectors more than 30 degrees from the resultant instead of less than 30 degrees from it.

HERBERT B. DWIGHT (F '26)

(Professor of electrical machinery, Massachusetts Institute of Technology, Cambridge, Mass.)

Testing Motors for Merchant Marine



This completed powerful propulsion motor, being tested at the Pittsfield (Mass.) Works of the General Electric Company, is one of many under construction for a fleet of vessels ordered by the United States Maritime Commission. The motors are manufactured in shops once devoted mainly to production of large power transformers

NEW BOOKS • • •

The following new books are among those recently received from the publishers. Books designated ESL are available at the Engineering Societies Library; these and thousands of other technical books may be borrowed from the library by mail by AIEE members. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books. All inquiries relating to the purchase of any book reviewed in these columns should be addressed to the publisher of the book in question.

Practical Physics. (Industrial Series.) By M. W. White, K. V. Manning, R. L. Weber, and R. O. Cornett. Prepared under the direction of the division of arts and science extension, Pennsylvania State College. McGraw-Hill Book Company, New York, N. Y., and London, England, 1943. 365 pages, illustrations, etc., $9^1/_2$ by 6 inches, cloth, $2.50. (ESL.)

This elementary, practical, and abbreviated text in introductory general physics is designed to meet a specific need created by the pressure of wartime conditions. Primary emphasis is placed upon the basic principles of those portions of physics that are of immediate use in war industry, technical work, and the armed services. Simple illustrative experiments are included.

Synthetic Resins and Allied Plastics. By various authors, edited by R. S. Morrell. 2nd edition. Oxford University Press, New York, N. Y.; Humphrey Milford, London, England, 1943. 580 pages, illustrations, etc., 9 by $5^1/_2$ inches, cloth, $12. (ESL.)

In the general introduction a summary is given of the chemical and physical properties of the most important classes of synthetic resins and plastics. Succeeding chapters deal with the technology of the preparation and use of these various classes of synthetics, with considerable space devoted to the problems of resinification. The last chapter discusses methods of identifying and testing synthetic resins and other raw materials of plastics. Chapter bibliographies are included.

Fundamentals of Electricity. By W. H. Johnson and L. V. Newkirk. The Macmillan Company, New York, N. Y., 1943. 212 pages, illustrations, etc., $11^1/_2$ by 8 inches, linen, $2. (ESL.)

This preinduction course in electricity is prepared in accordance with United States Army specifications for skilled training. It covers basic magnetic and electrical theory; describes the construction and operation of typical electrical apparatus, including storage batteries, meters, motors, and rectifiers; and illustrates all topics by means of effective photographs and diagrams. Many practical laboratory experiments are included.

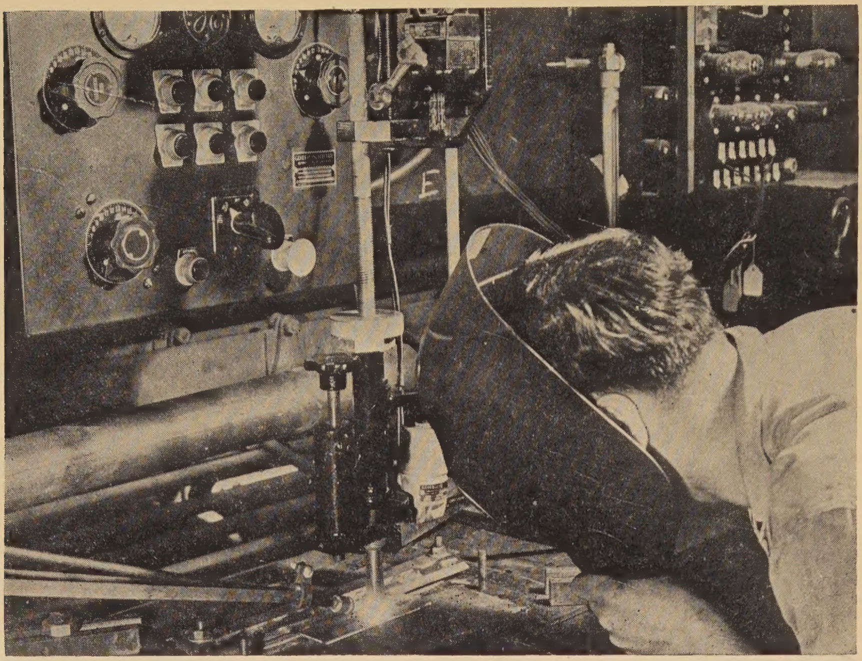
Alternating Currents for Technical Students. By C. C. Bishop. 2nd edition. D. Van Nostrand Company, New York, N. Y., 1943. 424 pages, illustrations, etc., 8 by $5^1/_2$ inches, cloth, $2.50. (ESL.)

The purpose of the book is to explain graphically and with simple mathematics the fundamental principles of a-c theory, circuits, and apparatus. In this second edition, some of the material has been rearranged and expanded to conform with changes in recent years. In particular, a chapter on complex quantities has been added, and their application to circuit problems is shown and compared with the step-by-step method of solution.

Refrigerating Data Book and Catalog, 5th edition. American Society of Refrigerating Engineers, New York, N. Y., 1942. 518 pages, catalog section, 160 pages, illustrations, etc., $9^1/_2$ by $6^1/_2$ inches, fabrikoid, $4. in United States, $4.50 other countries. (ESL.)

This edition of this well-known reference

New Automatic Helium-Shielded Arc Welder



Under a shield of helium gas which affords precise control of concentrated heat and protects the molten metal from the oxidizing effect of oxygen in the air, this newly designed automatic arc-welding equipment, in operation at General Electric Company, Schenectady, N. Y., makes smooth clean welds at rates up to 40 inches per minute on $^1/_8$-inch stock. The electronic control panel at the right controls arc length even while the arc climbs and descends inclines; the slanting tube at the lower left directs filler wire into the arc at the correct angle and at a predetermined rate of speed; and the tungsten electrode and gas nozzle are carried by the rod perpendicular to the work. All operations are controlled at upper left panel

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book has been revised thoroughly and reset in more readable form. It is substantially a revision of the 1939 edition, devoted chiefly to the basic principles and data of refrigeration and to the major kinds of refrigerating and air-conditioning machinery.

Ferromagnetism. By J. R. Ashworth. Taylor and Francis, London, E.C.4, England, 1943 printing, first published in 1938. 97 pages, charts, etc., 9 by $5^1/_2$ inches, cloth, 7s. 6d. (ESL.)

The contents of this book are confined closely to the development of a ferromagnetic equation based on the analogy of the fluid laws. This development depends to a considerable extent upon the application of van der Waals' equation of state to magnetism. The material in the book is a revised and co-ordinated presentation of the results of experiments published over a long period in various English scientific journals.

Dynamical Analogies. By H. F. Olson. D. Van Nostrand Company, New York, N. Y., 1943. 196 pages, diagrams, etc., 9 by $5^1/_2$ inches, cloth, $2.75. (ESL.)

This book deals with the analogies between electrical, mechanical rectilineal, mechanical rotational, and acoustical systems. By means of analogies, the knowledge of electric circuits may be applied to the solution of problems in mechanical and acoustical systems. The subject matter is developed in stages from the simple element to complex arrangements of multielement systems. The text assumes a familiarity with the elements of a-c theory and physics.

Small Arms Manual. By J. A. Barlow and R. E. W. Johnson. Revised edition. John Murray, Albemarle Street, London W., England, 1942. 232 pages, diagrams, etc., $5^1/_2$ by 4 inches, flexible, $1. (ESL.)

The major part of this manual is devoted to detailed instructions for the operation, taking down, and assembling of various types of small arms, chiefly of British manufacture. The classes covered are rifles, light machine guns, machine carbines, revolvers, and automatic pistols. Ammunition and special features are noted, and there is brief information on the functions in battle of these types of weapons.

Ceramic Trade Directory, 1943. 6th edition. Ceramics Publishing Company, Newark, N. J. 300 pages, illustrations, etc., 7 by $4^1/_2$ inches, fabrikoid, $6. (ESL.)

Informative data are presented concerning companies engaged in the ceramic industries, classified with respect to character of ware manufactured. There are also a complete geographical index to companies and plants and an alphabetical index of company officials. A buyers' guide to materials and equipment, a list of technical and trade associations, and a list of trade names of ceramic wares are included.

The City, Its Growth, Its Decay, Its Future. By E. Saarinen. Reinhold Publishing Corporation, New York, N. Y., 1943. 380 pages, illustrations, etc., $9^1/_2$ by 6 inches, cloth, $3.50. (ESL.)

A noted architect here presents his views on city planning in the form of an analytic study of the urban community. How this community during historic time has been born, has grown, has aged, and then decayed are described, and why all this happened is shown. The remedies are considered. The subject is presented from the layman's viewpoint, and the book will interest many who are not professionally concerned.

Electronic Control of Resistance Welding. By G. M. Chute. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1943. 389 pages, illustrations, etc., $9^1/_2$ by 6 inches, cloth, $4. (ESL.)

This textbook is based on experience in preparing men without technical training to keep resistance welding equipment in service. Electron tubes and their circuits, as used to control welders, are described in detail with diagrams of the circuits. Synchronous timers and stored-energy controls are explained. The text is simple and practical.

PAMPHLETS . . .

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Preliminary Statement of "The Gray Plan" for Postwar Re-employment. Carl A. Gray. The Grenby Manufacturing Company, Plainville, Conn., 1943. 40 pages, no charge.

Handbook of Production Controls. Research Institute of America, 292 Madison Avenue, New York 17, N. Y., 146 pages, $2.00.

Plan Postwar Jobs—Now. Committee for Economic Development, Suite 3311, Department of Commerce Building, Washington 25, D. C., 32 pages.

Accident Facts, 1943 Edition. National Safety Council, Inc., 20 North Wacker Drive, Chicago 6, Ill., 96 pages, 50 cents per copy for orders of one to ten copies. Reductions on larger orders.

Testimony to the Future. National Association of Manufacturers, 14 West 49th Street, New York 20, N. Y., 20 pages.